APPENDIX A

Species Profiles

Part One: Invertebrates

SPECIES PROFILE

Barrens Itame

Itame sp. 1

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G3G4
State Rank: S1S2
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Barrens itame occupies pine barrens (NatureServe 2005), particularly those areas that have been recently burned (Mello 1998). This species also occurs in Appalachian oak-pine woodlands composed of a dense scrub oak understory and greater canopy closure (NatureServe 2005). Larval host plants have not yet been documented, though captive specimens have been reared using scrub oak (Wagner et al. 2003), and various heath species (Ericaceae) are plausible food items (USAF 2002, Mello 1998). For a detailed habitat description refer to the pine barrens habitat profile.

1.2 Justification

The Barrens itame, along with other pine barren specialists, serves as an indicator of ecological condition. In the absence of disturbance or management, Barrens itame populations decline and become increasingly vulnerable to extirpation. Declines are likely a reflection of the loss of the vital compositional and structural elements of pine barrens (e.g., scrub oak understory) with increasing canopy closure.

1.3 Protection and Regulatory Status

NHNHB (2005) identified the Barrens itame as an important sprecies, but it is currently not protected.

1.4 Population and Habitat Distribution

The range of the Barrens itame extends from Maine to Virginia, and west to New York and Pennsylvania. Most occurrences are in high quality pine barrens of New Jersey. Barrens itame are believed to be more widespread in the Cape Cod and Islands region of Massachusetts, and probably on Long Island, New York (NatureServe 2005). In New Hampshire, specimens were collected in 1985 and 1995 at the West Branch Pine Barrens Reserve in Tamworth. For details regarding habitat distribution, see pine barrens habitat profile.

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See pine barrens habitat profile

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine habitat and distribution of the Barrens itame.

1.8 Extent and Quality of Data

The quality and extent of the data for the Barrens itame in New Hampshire are limited to the recorded sightings in Tamworth. Other areas where pine barrens occur in New Hampshire have not been surveyed for the Barrens itame.

1.9 Distribution Research

Additional surveys should be conducted to determine distribution, habitat requirements, and life

history traits of the Barrens itame. Current populations should be monitored for trends, while new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4

See the Karner blue butterfly profile and pine barrens profile

Element 5: References

5.1 Literature

United States Air Force (USAF). 2002. Threatened and Endangered Species and Fire Management at the Cape Cod Airforce Station, Massachusetts.

Wagner, D.L., M.W. Nelson, D.F. Schweitzer. 2003. Shrubland Lepidoptera of southern New England and southeastern New York: ecology, conservation, and management. Forest Ecology and Management 185:95-112.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Barrens Xylotype

Xylotype capax

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S2
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The barrens xylotype in New Hampshire occupies pitch pine-scrub oak woodland (NatureServe 2005), an early-successional community dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). Larval host plants of the barrens xylotype include blueberry (*Vaccinium sp*.), cherry (*Prunus sp*.), crabapple (*Malus sp*.) and red oak (*Quercus rubra*) (Covell 1984). The flight period is August though November, with a peak in October. For a detailed habitat description, refer to the pine barrens habitat profile.

1.2 Justification

The barrens xylotype, along with other pitch pine-scrub oak woodland specialists, serves as an indicator of ecological condition. In the absence of disturbance or management, barrens xylotype populations decline and become increasingly vulnerable to extirpation. Declines likely reflect the loss of the vital compositional and structural elements (e.g., heath and stratum *Prunus* spp.) in pitch pine scrub-oak woodlands with increasing canopy closure.

1.3 Protection and Regulatory Status

NHNHB (2005) identified the barrens xylotype as an important species, but it is currently not protected.

1.4 Population and Habitat Distribution:

The barrens xylotype range includes southern Maine to Maryland, west to Manitoba and southeastern Kentucky (Colvell 1984). Distribution is spotty in the north and greater in the south (McCabe 1995). It is uncommon to rare inland and in the Northeast (Wagner 2000). In New Hampshire, the barrens xylotype has been recorded at 4 sites, including the Concord Pine Barrens in Concord (1991, 2000), the West Branch of the Ossipee Pine Barrens in Madison (1985), the Hookset Riverbluff Barrens (1985), and in the town of Milford (1875) (VanLuven 1994, Chandler 2000).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile and the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine the barrens xylotype habitat and distribution.

1.8 Extent and Quality of Data

Lepidopteron surveys conducted at the Concord Pine Barrens have recorded this species. Other areas where pitch pine-scrub oak woodlands habitat occurs in New Hampshire have not been surveyed for the barrens xylotype.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of the barrens xylotype. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed.

Elements 2-4

See the Karner blue butterfly profile and the pine barrens profile

Element 5: References

5.1 Literature

Chandler, D.S. 2002. New Hampshire Army National Guard butterfly and moth survey, 2001 final report. University of New Hampshire. Durham, New Hampshire, USA.

Covell, C.V., Jr. 1984. Peterson Field Guides: Eastern Moths. Houghton Mifflin Company, New York, New York, USA.

McCabe, T.L. 1995. The changing insect fauna of Albany's pine barrens. In: Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. U.S. Department of the Interior, National Biological Service, Washington, D.C.

VanLuven, D.E. 1994. Site Conservation Plan for the Concord Pine Barrens, Concord, New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

Wagner, D.L. 2000. The Macrolepidoptera Fauna of Mount Everett, Massachusetts. The Nature Conservancy, Boston, Massachusetts, USA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Brook Floater

Alasmidonta varicosa

Federal Listing: Not Listed
State Listing: Endangered
Global Rank: G3
State Rank: S1
Author: Barry J. Wicklow, Department of Biology, Saint Anselm College

Element 1: Distribution and habitat

1.1 Habitat Description

Brook floaters are strictly riverine species inhabiting small streams to large rivers with high to moderate flows. They are absent in scour-prone areas of high gradient streams and avoid high velocity flow channels. Although they show no consistent substrate preference (Strayer and Ralley 1993), brook floaters in New Hampshire are often found in gravel and in sand among larger cobble in riffles, along shaded banks, and, in higher gradient streams, in sandy flow refuges behind large boulders (S. von Oettingen, USFWS, personal communication, B. Wicklow, Saint Anselm College, personal observation). They are found most often in nutrient-poor streams with low calcium levels (Strayer 1993). Mussels are suspension feeders, subsisting on phytoplankton, bacteria, fine particulate matter, and dissolved organic matter (Strayer 2004).

As in other unionid mussels, brook floaters' life cycle is complex and parasitic. Spawning occurs in summer as sperm are released into the water column, where they are drawn into the inhalent aperture of the female and into the outermost demibranchs of the gills, which function as marsupia. There the eggs are fertilized and develop and mature into larvae called glochidia. Brook floaters are long-term brooders. In New Hampshire, glochidia are held through the winter until release, which begins in mid-April and continues through May (B. Wicklow, Saint Anselm College, unpublished data). Glochidia must attach to a host fish in order to complete development and disperse.

The brook floater is a host generalist. Glochidia are capable of transforming on a variety of host fish species: longnose dace, *Rhinicthys cataractae*, blacknose dace, *Rhinicthys atratulus*, golden shiner, *Notemigonas chrysoleucas*, pumpkinseed sunfish, *Lepomis gibbosus*, yellow perch, *Perca flavescens*, tessellated darter, *Etheostoma olmstedi*, mad tom, *Noturus insignis*, and sculpin, *Cottus cognatus* (Wicklow and Wicklow, Saint Anselm College, unpublished data). Gravid female brook floaters release glochidia in loose masses that drift downstream. Transformation of encysted glochidia takes 3 to 4 weeks at 15^0 C. Upon release, juveniles burrow immediately into the substrate (Wicklow and Wicklow, Saint Anselm College, unpublished data).

1.2 Justification

Freshwater mussels are the most imperiled fauna in North America, having suffered steep declines in diversity, abundance, and distribution within the last 200 years (Richter et al. 1997, Lydeard et al. 2004). In the genus *Alasmidonta* 9 of 13 species are threatened, endangered, or extinct (Williams et al. 1992). The brook floater was a federal candidate species for listing under the Endangered Species Act until the candidate category was removed by congress in 1995. An Atlantic slope species, the brook floater once ranged from Nova Scotia to South Carolina and was widespread throughout much of its range. Populations have since declined sharply and in many states are considered rare or are extirpated. Many populations are small, have low densities, and show little or no evidence of recruitment. Brook floaters have declined in much of the south and are critically

imperiled in New Hampshire, Connecticut, Massachusetts, Maryland, and Virginia and are presumed extirpated in Rhode Island and Delaware.

The range has contracted in New York, although a robust population still exists in the Neversink River (Strayer 1997, Strayer and Ralley 1991). It has disappeared from many other New York locations including the Housatonic and Passaic basin and has declined severely in the Susquehanna basin (Strayer 1997, Strayer and Fetterman 1999, O'Brien, New York Department of Environmental Conservation, personal communication). It occurs in fewer than 12 streams in Connecticut (Nedeau 2002). It is threatened in Vermont, where it is restricted to the West River (Fichtel and Smith 1995) and in Maine is a species of special concern, occurring in most rivers that historically supported Atlantic salmon (Nedeau et al. 2000). Human activity has jeopardized populations through riparian disturbance, pollution, sedimentation, dams, impoundments, and artificial flow regimes. Stream fragmentation disrupts mussel life cycles, prevents host fish migration, blocks gene flow, and prohibits re-colonization resulting in reduced recruitment rates, decreased population densities, and increased probability of local extinctions (Neves et al. 1997, Watters 1999, Strayer et al. 2004).

1.3 Protection and Regulatory Status

- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats, including the banks of rivers and streams.
- The Shoreland Protection Act (NHDES, RSA 483-B) limits the amount of tree removal and other activities within 250 ft of major rivers and requires a primary structure setback of at least 50 ft.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)- state endangered.
- Rivers Management and Protection Program; NHDES (RSA 438) designates rivers in New Hampshire for protection of cultural or natural resources and stipulates the following: no channel alteration activities shall be allowed in rivers designated as "natural;" no dams will be built on rivers designated as natural, rural or rural community rivers; a protected instream flow level shall be established for each designated river; no motorized watercraft are allowed on designated natural rivers; within 15.24 m (50ft) of a stream, 50% of basal area of trees cannot be cut. For fourth order streams and higher this extends to within 45.72 m (150 ft).
- Local regulations and zoning varies considerably.

1.4 Population and habitat distribution

Brook floaters require clean well-oxygenated streams with moderate to high flows. In New Hampshire, brook floaters occur in the Connecticut and Merrimack Rivers and in coastal watersheds. Over 70 % of reported populations have less than 30 individuals. Stream fragmentation resulting from dams, causeways, impoundments, channelization, and inhospitable stream segments results in spatially and genetically disjunct populations. Many populations have densities that put them in jeopardy of extirpation from stochastic demographic, genetic, or environmental events. Brook floaters in New Hampshire have very small linear ranges making them especially vulnerable to human impacts.

Only one state population occurs within the Connecticut River Watershed: the North Branch of the Sugar River (Cutko 1993). Several populations are found within the Merrimack River Watershed: the Blackwater, Piscataquog, Suncook, Soucook Rivers and in Merrimack River main stem (Cutko 1993, Gabriel 1995, NHNHB 1996, Wicklow, Saint Anselm College, unpublished data). Brook floaters exist in very low numbers or have been extirpated from the Nissitissit River in Hollis, Golden Brook in Windham, and Beaver Brook in Pelham where a population was first reported by Athearn and Clarke in 1952 (Clarke 1981, Gabriel 1995). In the coastal drainage, brook floater populations are in danger of extirpation. They appear to be gone from the Exeter River and are scattered in very low numbers in the Lamprey River (Cutko 1993, Albright 1994, Gabriel 1996, Wicklow, Saint Anselm college, unpublished data).

1.5 Town Distribution Map

A map is provided

1.6 Habitat Map

Not completed for this species

1.7 Sources of Information

Information on the life history, habitat, and distribution of brook floaters was obtained from the scientific literature, unpublished reports, databases, expert consultation, and unpublished research results.

1.8 Extent and Quality of Data

Most information on brook floater populations is qualitative and was acquired in the mid-1990s or earlier. Early surveys efforts employed Catch Per Unit Effort (CPUE) methods, and while helpful in determining presence of absence, these methods are not statistically valid and therefore cannot be reliably used to determine population changes or trends. In 1996, Wicklow began a 10-year quantitative study of the brook floater population in the main stem of the Piscataquog River in Goffstown. The population was monitored in 1996, 1997, 1999, 2004, and will be monitored again in 2005 and 2006 (Wicklow, Saint Anselm College, unpublished).

1.9 Distribution Research

Locations last visited in 1993 or 1995 need to be resurveyed to determine if brook floaters still exist. Sites in each of the three watersheds should be monitored. Priority sites for quantitative monitoring include: 1) the Lamprey River in Lee from Wadleigh Falls to Wiswall Dam, 2) the Blackwater River in Webster at the Webster Elementary School and Snyders Mills sites, 3) the Piscataquog River in Goffstown at the Henry Bridge site, 4) the Soucook river in Loudon, 5) the Suncook River in Epson, 6) the Merrimack River at Sewalls Falls, and 7) the North Branch of the Sugar River in Croyden. Surveys are needed in the Connecticut River Watershed, where the North Branch population is the only known occurrence.

All sites should be resurveyed for presence. Quantitative, statistically valid monitoring of the largest populations is needed.

Element 2: Species/ habitat condition

2.1 Scale

Brook floaters are present in three major river basins. Dams and inhospitable river reaches – current or historic – have fragmented larger populations, which now exist in small patches that are spatially and genetically isolated. Flood stage shear stress and substrate stability may limit he distribution of brook floaters within the scale of the river reach, less than1 kilometer (Layzer and Madison 1995, Strayer 1999, Hastie et al. 2001). Other potential influences are water depth and temperatures during low water periods.

2.2 Relative health of populations

Based on evidence of recruitment and abundance observed during CPUE surveys in 1993 and 1995, the Blackwater, Suncook, Soucook, and the North Branch Sugar River populations appear the most robust. Nevertheless the North Branch Sugar River population is small and insular and therefore at risk of harm from pollution and habitat degradation. Mussel populations end abruptly at the North Branch and Sugar River confluence where water quality is low (von Oettingen, USFWS, personal communication). Long-term monitoring of the Piscataquog River Henry Bridge population shows a decline in mussel density from 0.4 per meter squared in 1996 to 0.02 in 1999 (Wicklow, Saint Anselm College, unpublished data). A mussel bed on the South Branch of the Piscataquog River, monitored periodically since 1993, has been nearly extirpated. The coastal watershed populations are at high risk of extirpation.

2.3 Population management status

Mussel relocation during bank stabilization and bridge replacement projects requires wetland permits. A river restoration project upstream of a brook floater subpopulation is in progress on the Piscataquog River.

2.4 Habitat patch protection status

Very little habitat information exists. Most brook floater populations have not been assessed in over 10 years and ecological attributes have not been measured. Although brook floaters are capable of using a wide range of host fish, research on glochidial infestation of fish in natural populations has not been conducted. Research is needed to determine population size, density, and recruitment, and to assess water quality.

2.5 Habitat patch protection status

Little habitat protection exists for brook floater populations, though local and state organizations are beginning to address conservation.

2.6 Habitat management status

There is little management of brook floater habitat. However, the Lamprey River, designed as a Wild and Scenic River, was surveyed for brook floaters in 1993, 1994, and 1996 (Cutko 1993, Hibright 1994, Gabriel 1996).

2.7 Sources of information

Distribution data were obtained from the New Hampshire Natural Heritage Bureau Element Occurrence Database, unpublished reports, scientific literature, and consultation with experts.

2.8 Extent and quality of data

Nearly all the information on the condition of brook floater populations and habitat is qualitative and is based on CPUE methods. Needed are quantitative studies to assess habitat attributes such as sediment type and hydraulics, particularly shear, and water quality. Also needed are data on brook floater population structure, age class distribution, sex ratio, recruitment, growth rates, and dispersal, as well as distribution and abundance data on host fish. Studies that examine the effects of predation and competition are also important.

2.9 Condition ranking

To be provided by NHFG

2.10 Condition Assessment Research

Research is needed to determine the effects of extreme fluctuating artificial flow regimes displacement of juveniles and glochidia, interference of spawning success, glochidial release patterns, and glochidia-host fish attachment success. Also important are DNA studies to determine the genetic consequences of stream fragmentation on dwarf wedgemussel (King 1999). Mark-recapture techniques should be used to estimate survival, recruitment, and population growth of brook floaters (Villella et al. 2004). In addition, the possibility of relocating mussels to rehabilitated habitats should be investigated.

Element 3: threat assessment

3.1.1 Altered Natural Hydrology

(A) Exposure pathway

The conversion of free-flowing rivers to highly regulated rivers has seriously affected freshwater mussels (Locke et al. 2003, Watters 1996, Watters 1999). Barriers cause direct mortality, prevent dispersal, block gene flow, prohibit re-colonization of rehabilitated habitat, and prevent host fish migration (Layzer et al. 1993, Parmalee and Hughes 1993, Vaughn and Taylor 1999, Watters 1996).

Cycles of extreme episodic flooding and dewatering use cause direct adult mortality by scouring. Extreme fluctuations in flow disrupt mussels by exposing glochidia and juveniles to flood-induced damage, mortality, or displacement to unfavorable habitat downstream (Layzer et al. 1993, Layzer and Madison 1995, Hardison and Layzer 2000). Dewatering exposes mussels to heat, desiccation, and opportunistic predators. Predator foraging efficiency increases with decreasing depth.

(B) Evidence

Dams have separated brook floater populations in every river system they inhabit. Barriers decrease the size of linear ranges. Isolated mussel populations are more susceptible to pollution and habitat degradation (Strayer et al. 1996).

In 1999, Wicklow showed a correlation between presence of glochidia and high flow releases from the Surry Mountain Dam on the Ashuelot River (Wicklow, Saint Anselm College, unpublished data). During a period of low water in 1997, 163 brook floaters in a population downstream from the Gregg Falls Hydroelectric Dam on the Piscataquog River were lost to predation (Wicklow, Saint Anselm College, unpublished data).

In addition, over 100 dwarf wedgemussel valves were collected from muskrat middens in a 15-meter segment of the Ashuelot River during a period of extremely low water (von Oettingen, USFWS and Wicklow, Saint Anselm College, unpublished).

3.1.2 Non-point Source Pollution

(A) Exposure pathway
Runoff from municipalities, industrial waste, sewage outfalls, golf courses, and poorly managed agricultural and silvicultural land contributes to water quality degradation, increasing sedimentation and organic pollution. As development increases, impervious surfaces increase the volume and velocity of runoff, causing erosion, sedimentation, and high levels of toxins in rivers and streams. Riparian vegetation is critical in retarding these effects.

Mussels are sensitive to heavy metals introduced through runoff and atmospheric deposition, as well as to toxins, such as chlorine and ammonia (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are most sensitive to pollutants. Because juveniles and adults burrow into and feed within the sediments, oxygen-poor and toxin-rich sediment may be a major pathway for contamination (Newton et al. 2003, Poole and Downing 2004).

(B) Evidence
The effect of acute pollution on freshwater mussels is well documented (Neves et al. 1997). The most widely reported sources of pollution are poor land use practices (Neves et al. 1997, Poole and Downing 2004)). For example, hundreds of mussel species were killed, including federal and state listed species, by waste runoff from a small farm in the Connecticut River Watershed (USFWS 2002). Chemical and agricultural waste spills also cause direct mussel mortality, though the effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are more sensitive to toxins than glochidia (Cherry et al. 2005).

3.2 Sources of Information

Information was gathered from the scientific literature, reports, consultation with experts and personal research.

3.3 Extent and quality of data

Threats to freshwater mussels and their habitats are well documented. The synergistic and long-term effect of chronic stresses on freshwater mussels is not known.

3.4 Threat assessment research

New surveys of brook floater populations are needed in order to assess and monitor threats. The North Branch of the Sugar River population is small and isolated and therefore may be strongly divergent compared with other New Hampshire populations. Funds for sequencing microsatellite DNA to determine the phylogenetic relationships of New Hampshire brook floater populations should be pursued. Mitochondrial DNA of brook floaters from the Piscataquog River has already been sequenced (King, USGS, unpublished data). Further research is needed to elucidate the life history of brook floaters, to determine the effects of hydraulics on glochidia and juveniles, and to assess glochidial infestation of host fish. Current USFWS toxicity testing of glochidia and juvenile mussels should continue (Cherry et al. 2005). Additional long-term monitoring sites should be established in each of the three watersheds where brook floaters occur and should include geomorphic, hydrologic, and water quality assessments. Relocation strategies need to be investigated.

Element 4: Conservation Actions

4.1.1 Restoration and management

(A) Stream fragmentation, altered flow regimes, pollution, riparian disturbance

(B) Justification
1. Stream fragmentation, and attendant gene flow restrictions, will be reduced by removing barriers such as nonfunctional dams, where feasible, by operating dams at "run of the river" flow regimes, and by rehabilitating degraded river reaches. These measures will increase dispersal and re-colonization of brook floaters into rehabilitated river reaches. Pollution may render stream reaches uninhabitable. Destruction and transformation of riparian corridors accelerates erosion, bank sloughing, and runoff leading to increased levels of stream toxins, sediment, and higher stream temperatures.
2. Dispersal increases the potential for persistence of species in patchy, unstable habitats such as rivers and streams. As mussels are established in new habitat, linear range, re-colonization, and population size increase. Protection of riparian corridors

through fee simple land acquisition, conservation easements, and private landowner cooperation will reduce pollution runoff and sedimentation.
3. Initially, action will focus within the river reach, less than 1 kilometer, and later expand to include the entire river.
4. Brook floater populations and habitats must be assessed prior to implementation. Mussels found below a dam removal site or rehabilitated river reach may appear within 3 to 5 years, but 10 to 20 years or more may be necessary to establish a viable population. Riparian protection and restoration will be a long-term effort.
5. As additional water quality and habitat assessment information is collected, efforts can be redirected or expanded.

(C) Conservation Performance Objective
The performance indicator is the presence of brook floaters downstream of former barriers. The number of reproducing subpopulations of brook floaters will indicate the success of the program. The performance indicator for protected or restored riparian corridors will be determined after population and habitat assessment.

(D) Performance Monitoring
Surveys of brook floater populations are needed. Surveys in subsequent years are intended to first detect mussels. Then, as populations enlarge, mussel sites should be monitored using quantitative, statistically valid methods. Water quality monitoring stations upstream of brook floater populations must be established.

(E) Ecological response objective
The habitat restoration response objective is to increase size and density of brook floater subpopulations. Decades may be needed to achieve the desired ecological response. Monitoring should indicate water quality improvement within 5 to 10 years. Additional survey and monitoring data are needed before response objectives can be quantified.

(F) Response monitoring
The initial response will be monitored with qualitative surveying. As mussel populations increase in size, quantitative methods will be used (Strayer and Smith 2003).

(G) Implementation
Surveys are needed to choose long-term, quantitative monitoring sites in the Blackwater, Lamprey, Suncook, Soucook, Merrimack Rivers, and the North Branch of the Sugar River. Long-term monitoring should continue in the Piscataquog River. A cooperative effort involving the NHFG and local conservation organizations is needed in order to develop site-specific conservation plans.

(H) Feasibility
Conservation partnerships have successfully restored river reaches and have protected open space that provides wildlife habitat and enhances water quality. Funding limits the success of these initiatives.

4.2 Conservation action research

Additional surveys, monitoring, and research are necessary in order to assess the efficacy of conservation action research.

Element 5: References

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SPECIES PROFILE

Broad-lined Catopyrrha

Erastria coloraria

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Broad-lined catopyrrha in New Hampshire occupies pitch pine-scrub oak woodlands (NatureServe 2005), which are early-successional communities dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). The primary larval host plant of *E. coloraria* is New Jersey tea (*Ceanothus americanus*), which is necessary for the presence of this species, but other possible food sources include clover (*Trifolium* sp.) and brambles (*Rubus* sp.) (Covell 1984). *E. coloraria* has two broods during the spring and summer, with flight periods occurring from late May to mid-June and mid-July to early August (VanLuven 1994). For a detailed habitat description refer to the pitch pine-scrub oak woodland community profile.

1.2 Justification

E. coloraria, along with other pitch pine-scrub oak woodland specialists, serves as an indicator of ecological condition. In the absence of disturbance or management, *E. coloraria* populations decline and become increasingly vulnerable to extirpation. Declines are likely a reflection of the loss of the vital compositional and structural elements (e.g., heath stratum and nitrogen-fixing plants) that are lost in pitch pine scrub-oak woodlands with increasing canopy closure.

1.3 Protection and Regulatory Status

NHNHB (2005) has identified the *E. coloraria* as a species of very high importance, but it is currently not protected.

1.4 Population and Habitat Distribution

The range for *E. coloraria* extends from Connecticut in the north to Florida in the south, and west to Minnesota and Texas (Colvell 1984). In New Hampshire, a single occurrence of *E. coloraria* has been documented in Concord (1976), although, this species is presently considered extirpated from the state (Schweitzer 1983).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly and Pine Barrens profiles

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine *E. coloraria* habitat and distribution.

1.8 Extent and Quality of Data

Lepidoptera surveys conducted at the Concord Pine Barrens have not generated any *E. coloraria* specimens. Other areas where pitch pine-scrub oak woodland habitat occurs have not been surveyed for *E. coloraria*.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of *E. coloraria*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4

See the Karner Blue Butterfly and Pine Barrens profiles

Element 5: References

5.1 Literature

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5.2 Data Sources:

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New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Cobblestone Tiger Beetle

Cicindela marginipennis

Federal Listing: Category 2
State Listing: Threatened
Global Rank: G2
State Rank: S1
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Cobblestone tiger beetles inhabit sandy cobble beaches on the upstream sides of islands and along the banks of free-flowing rivers (Dunn 1981, Nothnagle 1993, Leonard and Bell 1999). The upstream sides of islands are typically covered with pebbles and cobble-sized stones, while downstream ends are sandy (Leonard and Bell 1999). Vegetation is sparse at the upstream end with a moderate diversity of grasses, herbs, and forbs, and few shrubs and trees (Nothnagle 1993, Sperduto and Nichols 2004). Characteristic vegetation includes bladder campion (*Silene cucubalis*), sand cherry (*Prunus pumila*), dogbane (*Apocynum sibiricum*), blue-grasses (*Poa* spp.), bent grasses (*Agrostis* spp.), goldenrods (*Solidago* spp.), willows (*Salix* spp.), blackberries, and raspberries (*Rubus* spp.) (Nothnagle 1993, Sperduto and Nichols 2004). Riverine islands are subject to annual disturbance from frequent flooding and ice scouring in the spring, which maintains suitable habitat by eliminating encroaching vegetation from the cobbled shore (TNC 1995, Sperduto and Nichols 2004, NatureServe 2005).

Cobblestone tiger beetles concentrate in the middle of the cobbled shoreline, 20-50 m away from the water's edge (Nothnagle 1993, 1995; TNC 1995). This area is not heavily scoured or subject to heavy sedimentation and the vegetation is not dense (TNC 1995). The minimum required habitat size is approximately 0.08 ha (0.2 ac) with a sand and vegetation cover of 20-50% and cobble-sized stones ranging in diameter from 2.5-7.6 cm (1-3 in) (Nothnagle 1995). Cobblestone tiger beetles do not typically inhabit gravel or areas with large stones and boulders (Nothnagle 1995).

2.2 Justification

Because of their extremely restricted habitat, cobblestone tiger beetles are under constant threat from fluctuating water levels, dam and waterway construction, and human disturbance (TNC 1995). The 2-year larval period makes larvae particularly susceptible to long-term flooding. New Hampshire populations of cobblestone tiger beetles rarely exceed 100 individuals, which further increases the risk of local extirpation from a single event.

2.3 Protection and Regulatory Status

Cobblestone tiger beetles are protected under the New Hampshire Endangered Species Act RSA 212. The Connecticut River Protection Program states: "it is unlawful to kill or remove the beetle from its natural habitat", and the cobblestone tiger beetle is the town insect of Plainfield, New Hampshire (TNC 1995).

2.4 Population and Habitat Distribution

In 1995, there were roughly 25 populations of cobblestone tiger beetles rangewide (TNC 1995). Isolated populations occur throughout the eastern United States on the islands and banks of the Connecticut River in New Hampshire, Vermont, Connecticut, and Massachusetts, the White River in Vermont, the Cattaraugus and Upper Genesee Rivers in New York, the Delaware River in New Jersey, as well as other

large rivers in Indiana and Ohio (Dunn 1981, Nothngale 1995, TNC 1995, Leonard and Bell 1999). Cobblestone tiger beetles have been extirpated from the big rivers of Pennsylvania, West Virginia, Mississippi, and Alabama due to flooding of their habitat by dams (TNC 1995, NatureServe 2005).
In New Hampshire, populations of cobblestone tiger beetles only occur on islands in the upper valley of the Connecticut River (Dunn 1981, Dunn 1986, NHNHB 2005). These are high quality populations because of their size and minimal habitat disturbance (TNC 1995).

1.5 Town Distribution Map
A map is provided.

1.6 Habitat Map
Not completed for this species

1.7 Sources of Information

Sources of information include tiger beetle field guides, habitat and natural community guides, peer-reviewed journal articles, conservation plans, and the NatureServe database.

1.8 Extent and Quality of Data

Locations of cobblestone tiger beetles in New Hampshire have been well documented since their discovery in the 1960s (Dunn 1978, NHNHB, 2005). Habitat information is well covered in field guides and peer-reviewed journal articles, even thought these sources are 10-30 years old. Little is known about cobblestone tiger beetle movements and dispersal patterns. The larva of the cobblestone tiger beetle is not adequately described (Leonard and Bell 1999).

1.9 Distribution Research

- Resurvey known locations of cobblestone tiger beetles
- Conduct presence/absence surveys at other areas with similar habitat
- Initiate studies regarding movement, dispersal, and use of secondary habitats (e.g., sandy riverbanks)
- Monitor to detect long-term changes and patterns of abundance

Element 2: Species/Habitat Condition

2.1 Scale
Not applicable for this species

2.2 Relative Health of Populations

Cobblestone tiger beetles have been documented on Burnaps and Hart Islands in Plainfield, Chase Island in Cornish, Johnston Island in Lebanon, and Walpole Island in Walpole (TNC 1995, NHNHB 2005). They were first discovered in New Hampshire in the 1960s, but the exact location is unknown due to poor documentation (Dunn 1981). An attempt to locate this site was made in 1977 and several populations were found on islands near Plainfield, Walpole, and Cornish (Dunn 1981). Surveys in 1983 and 1993 indicate small but stable populations of cobblestone tiger beetles (Nothnagle 1993). Johnston and Burnaps Islands had the fewest cobblestone tiger beetles (10 and 7, respectively), whereas Walpole and Chase Island had the most (58 and 26, respectively) (Nothnagle 1993).

2.3 Population Management Status

Population management has not been documented and is not being conducted because of the uncertain distribution of cobblestone tiger beetles in New Hampshire and because of insufficient and dated information.

2.4 Relative Quality of Habitat Patches

Cobblestone tiger beetles are restricted to the open, cobbled, and sparsely vegetated areas of river islands. The upstream sections of Burnaps, Chase, Hart, Johnston, and Walpole Islands all provide suitable habitat for cobblestone tiger beetles. The lower sections of these islands support well-established floodplain forests, which do not provide adequate habitat due to heavy sedimentation and dense vegetation cover (TNC 1995). Appropriate habitats for cobblestone tiger beetles south of Walpole Island in the Connecticut River in Massachusetts and Connecticut, as well as in feeder streams, have not been surveyed (Nothnagle 1993).

2.5 Habitat Patch Protection Status

All islands that support cobblestone tiger beetles are protected under the state Endangered Species Act. The Connecticut River was designated as an American Heritage River in 1999. The Silvio O. Conte National Wildlife Refuge Act (1991) and the Rivers Management and Protection Act (RSA 483) protect the Connecticut River. Burnaps Island is owned by the town of Plainfield. Chase Island is a wildlife management area owned by NHFG where hunting and trapping of small game is permitted. Hart Island is privately owned and can be susceptible to timber removal and development. Johnston and Walpole Islands are owned by an unknown agency of the State of New Hampshire (TNC 1995).

2.6 Habitat Management Status

None of the islands that support cobblestone tiger beetles are actively managed because of the uncertain distribution of cobblestone tiger beetles in New Hampshire and because of insufficient and dated information.

2.7 Sources of Information

Sources of information include the NHNHB Element Occurrence Database, conservation plans, and field surveys and reports.

2.8 Extent and Quality of Data

Current population estimates of cobblestone tiger beetles do not exist. The last known survey was conducted in 1993 (Nothnagle 1993). Habitat quality has not been assessed since 1995 (TNC 1995).

2.9 Condition Assessment Research

Survey cobblestone tiger beetles to estimate current population sizes. Survey beach microhabitats, including substrate structure, composition, and physiology of known and potential sites to update habitat suitability. Identify factors limiting cobblestone tiger beetle populations. Evaluate feeder streams and unsurveyed islands and beaches.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Hydrology (River Flow Management)

(A) Exposure Pathway
Dams pose a threat to cobblestone tiger beetles by fluctuating water levels to a greater extent than natural flooding during spring melts and after heavy summer rains (Nothnagle 1993, TNC 1995). Upstream from islands that support cobblestone tiger beetles, the Wilder Dam has the capacity to raise and lower the water levels of the Connecticut River over a meter in the course of a day during the summer. This fluctuation increases high water duration and inundates the soils, potentially affecting the survival of cobblestone tiger beetle larvae and adults (Nothnagle 1993).

In addition, the Connecticut River has the greatest number of riverine ice jams in New Hampshire (USACE, Cold Region Research and Engineering Laboratory Ice Jam Database 2005). Eliminating or reducing seasonal ice-scouring on the upstream portions of islands that support cobblestone tiger beetles would create unsuitable habitat by allowing late-stage successional plants to encroach on the sparsely vegetated cobble substrates (Nothnagle 1993, TNC 1995).

(B) Evidence
Populations of cobblestone tiger beetles have become extirpated in Mississippi, West Virginia, and Pennsylvania due to flooding by dams (TNC 1995, NatureServe 2005). Populations in New Hampshire were under threat when 2 hydroelectric projects were proposed in the mid 1980s (TNC 1995). The Department of the Interior did not approve these projects because the dams would interrupt Atlantic salmon (*Salmo salar*) migration, inundate one of the last free-flowing stretches the Connecticut River and 150 acres of farmland, and impact rare plants and animals that use this stretch of river, including cobblestone tiger beetles (TNC 1995).

The United States Army Corps of Engineers, Cold Region Research and Engineering Laboratory considered ways to prevent ice damage to the Cornish-Windsor covered bridge, a historical landmark (TNC 1995). Their conclusion was to break up the ice and move it slowly downstream by increasing the

flow rate of water from the upstream Wilder Dam from 19 to 840 m^3/sec (700 to 30,000 ft^3/sec) (TNC 1995). This project was discontinued because the dam could not accommodate the high flow rate and the water fluctuations in the reservoir would be well over the federal regulation of 5 feet (TNC 1995). By adopting this action, the flow regime would have degraded cobblestone beetle habitat by altering the structure and vegetation of the islands.

3.1.2 Recreation

(A) Exposure Pathway
Canoeists, campers, and off-highway recreational vehicle users can crush cobblestone tiger beetle larvae and burrows and destroy their habitat.

(B) Evidence
In studies of other rare tiger beetle species, populations were small to nonexistent in areas of heavy recreation and larger in areas where recreation was limited and vehicles were prohibited (USFWS 1990). All islands that support cobblestone tiger beetles are subject to stopovers by canoeists, but Hart Island is the only island that is accessible to off-highway recreational vehicles during periods of low water levels (TNC 1995). Although the impacts of these vehicles on cobblestone tiger beetles have not been studied, recreational vehicles have been observed on Hart Island and USFWS personnel from the Vermont Field Office have erected barriers around this island to discourage recreational vehicle use (USFWS field trip report, unpublished data).

3.1.3 Introduced Species

(A) Exposure Pathway
Non-native vegetation can displace native vegetation, including rare plant species, which degrade the habitat of cobblestone tiger beetles.

(B) Evidence
Several non-native plant species are found on the islands that support cobblestone tiger beetles, including Japanese knotweed (*Polygonum cuspidatum*), leafy spurge (*Euphorbia esula*), and purple loosestrife (*Lythrum salicaria*). These species have begun to displace native vegetation in the sparsely vegetated areas used by cobblestone tiger beetles (Nothnagle 1993, TNC 1995).

3.2 Sources of Information

Sources of information include conservation plans, technical reports, field surveys, and tiger beetle recovery plans.

3.3 Extent and Quality of Data

Since cobblestone tiger beetle populations are so small and restricted, accurate threat information is limited, although potential threats are well documented. The effects of an altered hydrologic regime in New England are poorly documented.

3.4 Threat Assessment Research

- Monitor recreation and its impacts on cobblestone tiger beetle populations, particularly during the summer.
- Monitor water level and flow rate fluctuations caused by the Wilder and Bellows Falls Dams and their effects on cobblestone tiger beetle habitats and populations.

Element 4: Conservation Actions

4.1.1 Promote Education and Knowledge of Cobblestone Tiger Beetle Distribution and Habitat, Education and Outreach

(A) Direct Threats Affected
Recreational Disturbance

(B) Justification
1) The idea of an endangered or threatened insect is unfamiliar to many people. Educating the public about the islands that support cobblestone tiger beetles will raise the awareness needed to maintain one of the best populations.
2) Educating the public to avoid certain areas in the Connecticut River will allow established populations of cobblestone tiger beetles to increase and potentially colonize other suitable habitats.
3) Educational programs and materials will be targeted toward conservation groups and recreational users.
4) Education and outreach materials do not exist for the cobblestone tiger beetle, except for life history fact sheets. It is imperative that materials

be developed now to prevent this species from becoming extirpated.
5) As new locations of cobblestone tiger beetles are discovered and data are collected, education and outreach materials will be updated and restricted access areas will be posted at canoe launches and campgrounds.

(C) Conservation Performance Objective
Increase awareness of cobblestone tiger beetles and their habitats. Reduce or prohibit recreational use of islands and other potential habitats. Assemble a volunteer base for monitoring recreation and cobblestone tiger beetles at these sites.

(D) Performance Monitoring
Observe recreation to show a decrease in activity or avoidance of islands and other potential cobblestone tiger beetle habitat.

(E) Ecological Response Objective
Increase populations of cobblestone tiger beetles on islands where there is recreational disturbance.

(F) Response Monitoring
Monitor known and potential cobblestone tiger beetle habitats for increases in population sizes and productivity due to access restrictions at those sites.

(G) Implementation
Develop and post interpretive signs about the presence of cobblestone tiger beetles and their ecology on islands and at campsites and canoe launches along the Connecticut River. Post signs at popular launches and campsites to restrict canoeists, campers, and recreational vehicles during critical periods of cobblestone tiger beetle development. Partner with the Vermont Fish and Wildlife Department to develop public presentations and materials about cobblestone tiger beetles. Work with conservation organizations and land trust groups (e.g., Upper Valley Land Trust, Connecticut River Watershed Council, Connecticut River Joint Commissions) to include information about cobblestone tiger beetles in their public events and newsletters. Engage the Upper Valley Land Trust Easement Volunteers to monitor cobblestone tiger beetle habitats. Update the wildlife and natural resources sections of management plans for the Connecticut River (e.g., Connecticut River Corridor Management Plan, Silvio O. Conte National Fish & Wildlife Refuge Action Plan and Environmental Impact Statement, Instream Flow Uses, Values and Policies in the Upper Connecticut River Watershed) by including information on cobblestone tiger beetles and their habitats.

(H) Feasibility
The NHFG is limited in the staff and funding needed to develop and implement a cobblestone tiger beetle education and outreach strategy. Contact with Connecticut River conservation groups and land trusts regarding assistance in cobblestone tiger beetle education and outreach has not been made.

4.1.2 Inclusion of the Cobblestone Tiger Beetle in Water Flow Policies, Regulation and Policy

(A) Direct Threats Affected
Flooding of Habitat, critical

(B) Justification
1) When developing recommendations for water flow policies, include considerations for cobblestone tiger beetles so that flow regimes will not cause inundation of islands for extensive periods.
2) Prevent extended flooding of cobblestone tiger beetle habitats so that larvae can complete their life cycle, thereby increasing populations.
3) Cobblestone tiger beetle habitats are downstream from two dams on the Connecticut River and are in the direct path of alterations to the hydrologic regime.
4) In New Hampshire, cobblestone tiger beetles coexist with hydropower and fluctuating water levels. Instream flow policies will not change until there are proposed changes in dam operations that could affect cobblestone tiger beetle habitats.
5) As dam operations change, new policies for water flow will be developed and implemented.

(C) Conservation Performance Objective
Enforce current regulations on flow rates from upstream dams to protect downstream cobblestone tiger beetle habitats from becoming inundated by high water levels.

(D) Performance Monitoring

Monitor water levels of the Connecticut River in areas near known and potential cobblestone tiger beetle habitats.

(E) Ecological Response Objective
Prevent known and potential tiger beetle habitats from becoming inundated by increased water levels as a result of increased water flows from upstream dams.

(F) Response Monitoring
Monitor cobblestone tiger beetle habitats for increases in population sizes and productivity and monitor potential habitats for colonizations that result from regulated flow rates from upstream dams.

(G) Implementation
Review current instream policies and determine how cobblestone tiger beetles are being affected. Develop guidelines for instream flow that would benefit cobblestone tiger beetles. If they pose no threat to cobblestone tiger beetles, support the recommendations of the Connecticut River Corridor Management Plan and the Connecticut River Joint Commissions for instream flow uses, values, and policies for the upper Connecticut River watershed. Coordinate with Vermont to develop flow management policies for the Connecticut River that will benefit cobblestone tiger beetles. Assist the New Hampshire Department of Environmental Services by incorporating considerations for cobblestone tiger beetles in their instream flow rule. Review potential projects on the Connecticut River that might alter the hydrologic regime and negatively affect cobblestone tiger beetles.

(H) Feasibility
The NHFG is limited in the amount of knowledge regarding flow rates to develop recommendations. Contacts that might provide assistance have not been identified.

4.2 Conservation Action Research

The effects of proposed actions are unclear because adequate population estimates of cobblestone tiger beetles are lacking. Surveys of cobblestone tiger beetles have not been conducted in New Hampshire since 1993. It is imperative that known and potential cobblestone tiger beetle habitats be resurveyed to assess the population status. Before creating sound strategies to address the threats to cobblestone tiger beetles, the severity of the threats must be understood.

Element 5: References

5.1 Literature

Dunn, G. A. 1978. Tiger beetles of New Hampshire (Coleoptera: Cicindelidae). Thesis, University of New Hampshire, Durham, New Hampshire, USA.

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5.2 Data Sources

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New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

United States Army Corps of Engineers, Cold Region Research and Engineering Laboratory Ice Jam Database. 2005. Hanover, New Hampshire http: //www.crrel.usace.army.mil/ierd/ijdb/. Accessed 2005 March 22.

SPECIES PROFILE

Cora Moth

Cerma cora

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G3G4
State Rank: S1S2
Author: New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Cora moth occupies pitch pine-scrub oak woodlands in the north and bluff and ravine forests and riparian swamps in the south (NatureServe 2005). In New Hampshire, *C. cora* inhabits pine barrens (NatureServe 2005), an early-successional community dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). *C. cora* larvae feed on Pin cherry (*Prunus pensylvanica*), spend much of their lives as pupae within dead wood, and mature in early or mid-July. For a detailed habitat description refer to the pine barrens profile.

1.2 Justification

C. cora, along with other pine barrens specialists, serves as an indicator of ecological condition. As the habitat goes unmanaged and reverts to a closed canopy system, *C. cora* populations decline and become increasingly vulnerable to extirpation, a reflection of the loss of vital compositional and structural elements within the community.

1.3 Protection and Regulatory Status

C. cora is widely distributed throughout much of the United States and does not appear to need protection.

1.4 Population and Habitat Distribution

C. cora range extends from New Hampshire in the north to Wisconsin in the west and south to Florida and Louisiana (NatureServe 2005). Primarily a southern species, *C. cora* is spottily distributed throughout much of its range, with few to no occurrences in many of these states (VanLuven 1994). Other than Wisconsin, no other state has verified more than 5 occurrences (NatureServe 2005). In New Hampshire, this species has been documented in the Concord Pine Barrens (1983) as well as in the town of Webster (1898) (NHNHB 2005).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

See Karner blue butterfly species profile and the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine *C. cora* habitat and distribution.

1.8 Extent and Quality of Data

Lepidoptera surveys conducted at the Concord Pine Barrens have not resulted in any observation of the *C. cora* in recent years. Other areas where pine barrens habitat occurs have not been surveyed for *C. cora*.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat

requirements, and life history traits of *C. cora*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4: *See the Karner Blue Butterfly and the Pine Barrens profiles.*

Element 5: References

5.1 Literature:

VanLuven, D.E. 1994. Site Conservation Plan for the Concord Pine Barrens, Concord, New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

Wagner, D.L. 2000. The Macrolepidoptera Fauna of Mount Everett, Massachusetts. The Nature Conservancy, Boston, Massachusetts, USA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Dwarf Wedgemussel
Alasmidonta heterodon

Federal Listing: Endangered
State Listing: Endangered
Global Rank: G1
State Rank: S1
Author: Barry J. Wicklow, Department of Biology, Saint Anselm College

Element 1: Distribution and habitat

1.1 Habitat Description

Dwarf wedgemussels, *Alasmidonta heterodon*, are Atlantic slope species inhabiting small streams to large rivers with moderate flow. They are found in hydrologically stable areas within a variety of substrates including gravel and coarse sands, fine sands, and clays in depths from a few centimeters to several meters. Mussels are suspension and deposit feeders, subsisting on phytoplankton, bacteria, fine particulate organic matter, and dissolved organic matter (Strayer et al. 2004).

The dwarf wedgemussel's life cycle is complex. Gametogenesis occurs from May through July (Michaelson and Neves 1995). Spawning occurs in summer when sperm are released into the water column and drawn into the inhalant aperture of the female. Eggs are fertilized, undergo development, and mature in the outermost demibranchs of each gill, which function as marsupia. Well-developed glochidia are present in the Connecticut River mussels as early as late August. Dwarf wedgemussels are long-term brooders, holding glochidia through the winter until release begins in early March and continues through mid-June (Wicklow unpublished data). Glochidia must attach to a host fish in order to complete development and to facilitate dispersal. Host fish include the tessellated darter *(Etheostoma olmstedii)*, johnny darter *(Etheostoma nigrum)*, mottled sculpin *(Cottus cognatus)*, (Michaelson and Neves 1995), slimy sculpin *(Cottus cognatus)*, and juveniles and parr of the Atlantic salmon *(Salmo salar)* (B. Wicklow, Saint Anselm College, unpublished data). Due to fish range limitations, the tessellated darter, slimy sculpin, and Atlantic salmon are the only host fish available for dwarf wedgemussel glochidia in New Hampshire. The dwarf wedgemussel is the only species of *Alasmidonta* that uses a behavioral display to attract host fish (B. Wicklow, Saint Anselm College, unpublished data).

1.2 Justification

Freshwater mussels have declined dramatically in diversity, abundance, and distribution within the last 200 years and are considered the most imperiled fauna in North America (Richter et al. 1997, Lydeard et al. 2004). In the genus *Alasmidonta* 9 of 13 species are threatened, endangered, or extinct (Williams et al. 1992). Historically, the dwarf wedgemussels was found from the Petitcodiac River in New Brunswick, Canada to the Neuse River in North Carolina, and was found in 15 major Atlantic slope river systems (United States Fish and Wildlife Service (USFWS) 1993). It is now extinct in Canada, extirpated in the Neuse River, and present in low densities throughout much of its former range (USFWS, 2002 Range Wide Assessment Meeting).

Only 54 populations remain; 41 of these are estimated to contain fewer than 50 individuals and of these, 32 have fewer than 10 individuals or are possibly extirpated; 8 or 9 are estimated at between 50 and 1,000 individuals; 4 are estimated at between 10,000 and 100,000 individuals. Human impacts including riparian disturbance, pollution, sedimentation, impoundments, artificial flow regimes, and stream fragmentation disrupt mussel life cycles, prevent host fish migration, block gene flow, and prohibit recolonization, resulting in reduced recruitment rates,

decreased population densities and increased probability of local extinctions (Neves et al. 1997, Watters 1999, Strayer et al. 2004).

1.3 Protection and Regulatory Status

- Listed as endangered on Federal Endangered Species Act (listed on March 14, 1990)
- Clean Water Act-Section 404; administered by the Army Corp of Engineers and Environmental Protection Agency -- regulates discharge of dredge or fill material into "waters of the United States," including wetlands.
- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats, including the banks of rivers and streams.
- The Shoreland Protection Act (NHDES, RSA 483-B) limits the amount of tree removal and other activities within 250 ft of major rivers and requires a primary structure setback of at least 50 ft.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)- state endangered.
- Rivers Management and Protection Program; NHDES (RSA 438) designates rivers in New Hampshire for protection of cultural or natural resources and stipulates the following: no channel alteration activities shall be allowed in rivers designated as "natural"; no dams will be built on rivers designated as natural, rural or rural community rivers; a protected instream flow level shall be established for each designated river; no motorized watercraft are allowed on designated natural rivers; ithin 15.24 m (50ft) of a stream, 50% of basal area of trees cannot be cut; for fourth order streams and higher this extends to within 45.72 m (150 ft).
- Local regulations and zoning varies considerably.

1.4 Population and habitat distribution

Since the extirpation in Canada, the Connecticut River drainage in New Hampshire has held the largest remaining dwarf wedgemussel populations and represents the northern limit of the distribution (USFWS, 2002 Range Wide Assessment Meeting). Nevertheless, these populations are extremely patchy, clustered in scattered mussel beds.

Dwarf wedgemussels require unpolluted streams or rivers with high dissolved oxygen, moderate current, and stable substrata within refugia (Strayer 1993b, Strayer and Ralley 1993). Stream fragmentation from dams, causeways, impoundments, channelization, and inhospitable stream segments results in spatially and genetically disjunct populations. Perhaps 50% or more of populations have densities that put them in jeopardy of extinction from catastrophes or stochastic demographic, genetic, or environmental events. Though populations range from 100 to 10,000 individuals, densities are low enough (mean = 0.01 to 0.05 per square meter, Strayer et al. 1996) to cause concern. Because mussels are broadcast spawners, populations with low densities may suffer reduced fertilization success (Downing et al. 1993, McLain and Ross 2005), which may strongly limit recruitment. Dwarf wedgemussels occupy small, linear ranges, putting populations at higher risk from impacts of pollution, habitat degradation, and disease (Strayer et al. 1996).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Known occupied stretches of river are mapped in the Natural Heritage Bureau database. Future mapping efforts should identify suitable habitat that has not been surveyed.

1.7 Sources of Information

Information on the life history, habitat requirements, and distribution of dwarf wedgemussels was obtained form the scientific literature, unpublished reports, databases, expert consultation, unpublished research results, and mussel recovery meetings.

1.8 Extent and Quality of Data

Dwarf wedgemussels in the Connecticut River main stem have been surveyed and intermittently monitored since 1988. Early surveys were conducted by canoe and snorkeling in shallow water, usually within 15 meters of the bank. Later SCUBA surveys found a significant number of dwarf wedgemussels in depths greater than 1.5 meters. Most of the early monitoring efforts employed Catch Per Unit Effort (CPUE)

methods. While helpful in determining presence or absence, CPUE methods are not statistically valid and therefore cannot be reliably used to determine population changes or trends.

Dwarf wedgemussels in the Connecticut River main stem have been surveyed and intermittently monitored since 1988. Dams and reservoirs divide mussels into 3 spatially and genetically disjunct populations.

1. The northern population occurs within 29-kilometer river section from Northumberland to Dalton. It was surveyed in 1996. One location in this section between Lancaster New Hampshire and Lunenburg, Vermont has been monitored regularly since 1997 when 536 dwarf wedgemussels including 87 tagged specimens were relocated 100 meters upriver as part of a bank stabilization project. Over 4,000 dwarf wedgemussels were found within the study area in 2000 (Gloria and Wicklow 2001). The Moore and Comerford dams and reservoirs separate this population from populations downstream.
2. A second population may occur in the section of river from the Comerford Dam and McIndoe Falls to the Wilder Dam impoundment. Dwarf wedgemussels were historically present and may still be extant in this section. This section is a priority for SCUBA survey.
3. The third population occurs in scattered beds within a 27-kilometer river segment between Plainfield and Charlestown. Biologists surveyed and monitored this section periodically since 1988. Strayer surveyed this section in 1994, estimating a population size of between 20,000 and 100,000 individuals (Strayer et al. 1996). Since 1991, several site-specific surveys have been conducted (Gabriel 1996, O'Brien 2001, Nedeau 2002). Between 1991 and 1995 five sites were monitored, three of the five annually (Gabriel and Strayer 1995). These three sites were monitored again in 2001 (O'Brien 2001). A 400 x 10 m area at the Charlestown Fort at Number 4 site was surveyed in 2002 (Nedeau 2003).

The Ashuelot River population downstream of the Surry Mountain flood control dam has been periodically monitored since 1991 (Gabriel and Strayer 1995). In 2004, Nedeau conducted a quantitative survey of dwarf wedgemussels in the Ashuelot River downstream of the Surry Mountain dam. The method, described in Strayer and Smith 2003, is recommended for estimating population size, density, and spatial distribution (Nedeau 2004).

1.9 Distribution research

Quantitative, statistically valid monitoring methods in known Connecticut main stem populations are needed. Using SCUBA, additional segments of the Connecticut River main stem need to be surveyed. Of particular priority is the stretch of river from below McIndoe Falls to Lyme, New Hampshire (von Oettingen, USFWS, personal communication). Other areas include the river south of Charlestown and the northern section from Pittsburg to Colebrook.

Nedeau and Werle surveyed the Ashuelot River from Keene to Hinsdale, finding 13 individuals just upstream of Sawyer Crossing (Nedeau and Werle 2003). Dwarf wedgemussels were sparse or absent in other river segments. Although present water quality and habitat appear suitable for dwarf wedgemussel, a long history of pollution and habitat degradation decimated dwarf wedgemussels in the Ashuelot below Keene. The scattered groups of mussel found recently may have persisted in refugia or may represent a re-colonization from the source population downstream of the Surry Mountain Dam (Nedeau and Werle 2003). Dispersal distance of encysted glochidia on tessellated darters and sculpin is less than 100 meters, thus re-colonization of areas of local extinction would be slow (McLain and Ross 2005).

Element 2: Species/ habitat condition

2.1 Scale

Dams and reservoirs divide the Connecticut River main stem into 3 major segments, each containing spatially and genetically disjunct populations: 1) the northern section, upstream of the Moore and Comerford Dams, that includes the Dalton-Lancaster population, 2) a middle section downstream of the Moore and Comerford Dams that includes high potential habitat from Monroe to Lyme, and 3) a southern section downstream of the Wilder Dam that include the Plainfield-Charlestown population. Within these linear units, subpopulation exists in scattered patches

that may function together as a metapopulation. Likewise, the Ashuelot River population downstream of Surry Mountain Dam is separated from the main stem by inhospitable reaches and dams. Distribution of mussels at the scale of the river reach, less than 1 kilometer, may be determined by flood stage shear stress and sediment stability (Strayer 1999b, Layzer and Madison 1995, Hastie et al. 2001).

2.2 Relative health of populations

Based on the presence of young individuals, the north and south populations on the Connecticut River main stem and the Ashuelot population appear viable. The north Connecticut River population appears to be most robust.

2.3 Populations management status

Population management has been limited to relocation initiatives stemming from bank stabilization projects, such as along Route 2 in Lunenburg, Vermont and at the Fort at Number 4 site in Charlestown, New Hampshire.

2.4 Relative quality of habitat patches

Both north and south populations in the Connecticut River main stem are estimated at between 10,000 and 100,000 individuals. These populations have been surveyed qualitatively and are in need of quantitative, statistically valid monitoring. Nevertheless, the Lancaster, New Hampshire, and Lunenburg, Vermont sites have patches of high mussel density, with all age classes present, and a high density of tessellated darter host fish (Gloria and Wicklow 2000, Nedeau 2004). This section of river is free flowing from the Murphy Dam at Lake Francis in Pittsburg to the Moore Dam Reservoir in Littleton and hosts the most vigorous, viable population known. The Ashuelot River Population, also considered among the largest populations, extends from the Surry Mountain Dam to Swanzey and is estimated at 10,000 individuals. Two sites downstream of Surry Mountain Dam were monitored quantitatively. The site closest to the dam showed an age distribution skewed toward older individuals, with little evidence of recruitment, whereas the downstream site showed a wider age distribution, with evidence of recruitment (Nedeau 2004).

2.4 Habitat patch protection status

Very little habitat protection exists. The Army Corps of Engineers operates the Surry Mountain Flood control dam and holds land downstream to the East Surry Road Bridge.

2.6 Habitat management status

Currently there are no management or restoration efforts targeting dwarf wedgemussel habitat in the state. However, the Nature Conservancy, the Monadnock Conservancy, the Society for the Protection of New Hampshire Forests, and the Southwestern Regional Planning Commission have developed a conservation plan for the Ashuelot River Watershed (Zankel 2004). The Connecticut River Joint Commission is currently updating a Connecticut River Management Plan for the main stem (S. Francis, Executive Director, Connecticut River Joint Commission, personal communication). A recent USFWS initiative in riparian restoration in the Lancaster, New Hampshire to Lunenburg, Vermont reach of the Connecticut River failed due to lack of landowner cooperation (von Oettingen, USFWS, personal communication).

2.7 Sources of information

Distribution data were obtained from the New Hampshire Natural Heritage Bureau Element Occurrence Database, unpublished reports, scientific literature, and consultation with experts.

2.8 Extent and quality of data

Much of the information on the condition of dwarf wedgemussel populations and habitat is qualitative. Needed are quantitative studies to assess the physical habitat, including sediment type and hydrology, particularly shear, and water quality. Also needed are data on dwarf wedgemussel population structure, age class distribution, sex ratio, recruitment, growth rates, and migration, as well as distribution and abundance data on host fish. Studies that examine the effects of predation and competition would be helpful.

2.9 Condition ranking

To be provided by NHFG.

2.10 Condition assessment research

Research is needed to determine the biological response of dwarf wedgemussel to artificial flow regimes. Response variables include displacement of juveniles and glochidia, interference of spawning success, glochidial release patterns, and host fish attachment success. Also important are studies using micro satellite DNA markers to determine the genetic consequences of stream fragmentation on dwarf wedgemussel (King 1999). Villella et al. used mark-recapture techniques to estimate survival, recruitment, and population growth of freshwater mussels (Villella et al. 2004), and this technique could provide valuable demographic information for dwarf wedgemussel populations. Mussels were marked during a relocation project at the Lunenburg, Vermont bank stabilization site in 1997, and additional mussels were marked in 2003. A much larger sample size is needed to complete this study (Wicklow, Saint Anselm College, unpublished).

Element 3: Species and habitat threat assessment

3.1.1 Altered Hydrology

(A) Exposure pathway
The conversion of free-flowing rivers to highly regulated rivers has seriously affected freshwater mussels. Dams, causeways, reservoirs, gravel mining, dredging, channelization, poor land use, and municipal and industrial pollution have resulted in scattered populations. Barriers cause direct mortality, prevent dispersal, block gene flow, prohibit re-colonization of unoccupied but rehabilitated habitat, and prevent host fish migration (Layzer et al. 1993, Parmalee and Hughes 1993, Vaughn and Taylor 1999, Watters 1996).

(B) Evidence
On the Connecticut River main stem the Moore, Comerford, and Wilder Dams have divided dwarf wedgemussels into 3 populations. Dams on the Ashuelot River are also barriers to dispersal; in a survey in the Ashuelot River dwarf wedgemussels were absent below the Swanzey Dam (Nedeau and Werle 2003), and historic water and habitat degradation was apparent (Nedeau and Werle 2003). Notably, the 1968 construction of a causeway across the Petitcodiac River in New Brunswick Canada transformed a macro-tidal estuary into a shallow freshwater impoundment thereby eliminating diadromous fish including the Atlantic salmon (Locke et al. 2003), a host fish of the dwarf wedgemussel (Wicklow, unpublished data). By the 1980s, the dwarf wedgemussel had disappeared from the Petitcodiac River and in 1999 the Committee on the Status of Endangered Wildlife in Canada declared the dwarf wedgemussel officially extinct (Hanson and Locke 2000).

3.1.2 Altered Hydrology

(A) Exposure pathway
Cycles of extreme episodic flooding and dewatering use cause direct adult mortality by scouring. Extreme fluctuations in flow disrupt mussel life cycles by exposing glochidia and juveniles to flood-induced damage, mortality, or displacement to potentially unfavorable habitat downstream (Layzer et al. 1993, Richter et al. 1997). Dewatering exposes mussels to heat, desiccation, and opportunistic predators. Predator foraging efficiency increases with decreasing depth.

(B) Evidence
In 1999, Wicklow showed a correlation between presence of glochidia in stream drift samples and high flow releases from the Surry Mountain Dam on the Ashuelot River (Wicklow, Saint Anselm College, unpublished data). In addition, over 100 dwarf wedgemussel valves were collected from muskrat middens in a 15 m segment of the Ashuelot River during a period of extremely low water (von Oettingen, USFWS and Wicklow, Saint Anselm College, unpublished).

3.1.3 Non-Point Source Pollution

(A) Exposure pathway
As development increases and riparian vegetation buffers decrease, the effects of pollution on the biota in the Connecticut River and tributaries will increase. Runoff from municipalities, industrial waste, sewage outfalls, golf courses, poor agricultural and silviculture land contributes to sedimentation, organic pollution, and general water quality degradation (Poole and Downing 2004). Mussels are sensitive to toxins, such as chlorine and ammonia, and to heavy metals introduced through runoff and atmospheric deposi-

tion (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are the most sensitive to pollutants, juveniles because they burrow into and feed within the sediments. Thus sediment, particularly when low in pore-water oxygen and high in toxins, may be a major contamination pathway for infaunal juveniles, as well as for adults, who may also deposit feed (Newton et al. 2003, Poole and Downing 2004).

(B) Evidence
The effect of acute pollution on freshwater mussels is well documented (Neves et al. 1997). Chemical and agricultural waste spills cause direct mussel mortality. The most widely reported sources of pollution are poor agriculture practices (Neves et al. 1997, Poole and Downing 2004)); 20 dwarf wedgemussels and hundreds of other mussel species were killed by waste runoff from a small farm in the Connecticut River Watershed (USFWS 2002). The effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are much more sensitive to toxins than are glochidia (Cherry et al. 2005).

3.1.4 Introduced Species

Adult zebra mussels are transported from basin to basin while attached to boats, and larvae may be transported in bilge and bait bucket water. Zebra mussels compete with native freshwater mussels for food and may reduce food concentration to levels that cannot support native species (Caraco et al. 1997, Strayer 1999). Larvae of zebra mussels require calcium levels between 8 and 20 ppm in order to complete development, well within the levels in the Connecticut River (Michelle Babione, Wildlife Biologist, Silvio O. Conte National Wildlife Refuge, personal communication). Because zebra mussels tend to infest rivers greater than 30 meters wide, the Ashuelot River is at lower risk of invasion.
After their initial discovery in Lake Saint Clare in 1988, zebra mussels quickly spread throughout many regions of the United States and parts of Canada. Their effect on the decline of freshwater mussels in the Hudson River is well documented (Caraco et al. 1997, Strayer 1999). Zebra mussels are present in Lake Champlain in Vermont. Recently a zebra mussel was detected on a boat in a boatyard at Lake Winnipesaukee. This underscores our need to intensify boat ramp surveys, particularly at high-use boating areas and priority biological sites, such as dwarf wedgemussel habitat. High boat use lakes, such as Sunapee Lake, that connect to biologically sensitive areas and have the potential for further zebra mussel spreading should be targeted (Michelle Babione, Wildlife Biologist, Silvio O. Conte National Wildlife Refuge, personal communication).

3.2 Sources of Information

Information was gathered from the scientific literature, reports, consultation with experts, and personal research.

3.3 Extent and quality of data

Whereas not all threats have been documented specifically for dwarf wedgemussels and their habitat, there is documentation for threat effects on other unionid mussels. The synergistic and long-term effect of the multiple kinds of chronic stresses on freshwater mussels is not known.

3.4 Threat assessment research

Expand research to determine phylogeographic relationships of New Hampshire populations of dwarf wedgemussels, using micro satellite DNA sequences (King et al., unpublished data). Further elucidate the life history of the dwarf wedgemussel. Determine the effect of hydrology on the life history of dwarf wedgemussels. Compare patterns of glochidial release observed in the mussels in the Ashuelot River prior to and after the change to "run of the river" flow management at the Surry Mountain Dam. Continue USFWS toxicity testing of glochidia and juvenile mussels (Cherry et al. 2005). Establish long-term monitoring sites on the Connecticut River that include geomorphologic, hydrological, and water quality assessments. Identify the physical characteristics of dwarf wedge mussel habitat and survey potential habitats for the presence of dwarf wedgemussel. Investigate the potential for relocation strategies.

Element 4 - Conservation actions

4.1.1 Restoration and management

(A) Stream fragmentation, altered flow regimes, pollution, riparian disturbance, invasive species

(B) Justification
Reducing stream fragmentation by removing barriers such as nonfunctional dams and by rehabilitating degraded river reaches will increase dispersal and re-colonization of dwarf wedgemussels. As barriers to dispersal are removed, gene flow is enhanced and heterozygosity increases.

Pollution may render stream reaches uninhabitable. Destruction and transformation of riparian corridors accelerates erosion, bank sloughing, and runoff, leading to higher temperatures, toxin levels, and sediment levels. Dam impoundments and reservoirs have a higher probability of zebra mussel colonization than do free-flowing river segments. Greater attention should be paid to areas of high risk. More intense boat ramp surveys, particularly at high-use boating areas and priority biological sites are warranted.

Dispersal increases the potential for persistence of species in patchy, unstable habitats such as rivers and streams. As mussels are established in new suitable habitat patches, linear range, population size, and likelihood of re-colonization increase. Protection of riparian corridors through fee simple land acquisition, conservation easements, and private landowner cooperation will reduce pollution runoff and sedimentation in the Connecticut River main stem and the Ashuelot River.

Removal of a small dam on the Ashuelot River will open kilometers of new habitat. Ultimately the Ashuelot River may be free of barriers through to the Connecticut River main stem. Riparian protection and restoration will improve downstream water quality and habitat.

Mussels found below a dam removal site or in rehabilitated river reach may appear within 3 to 5 years, but 10 to 20 years or more may be necessary to establish a viable population. Riparian protection and restoration will be a long-term effort.

As additional water quality and habitat assessment information is collected, efforts can be redirected or expanded.

(C) Conservation performance objective: The performance objective is to restore the Ashuelot River to a free flowing condition free of physical barriers and inhospitable degraded river segments within 5 to 10 years. The performance indicator is the presence of dwarf wedgemussels downstream of former barriers. The number of reproducing subpopulations of dwarf wedgemussel will indicate the success of the program. The performance indicator for protected or restored riparian corridors is 25 to 35% additional riparian protection along the Ashuelot River in 10 years and 15 to 20% additional riparian protection along the Connecticut River main stem in 10 to 20 years.

(D) Performance monitoring: The Ashuelot River was surveyed from Keene to Hinsdale between 2001 and 2003 (Nedeau and Werle 2003). Surveys in subsequent years are intended first to detect mussels. Then, as populations enlarge, mussel sites should be surveyed using quantitative, statistically valid methods. Water quality monitoring stations upstream of dwarf wedgemussel populations must be established.

(E) Ecological response objective: The habitat restoration response objective is to increase size and density of dwarf wedgemussel subpopulations downstream from Keene to Hinsdale and the mouth of the Connecticut River main stem. Decades may be needed to achieve the desired ecological response. Monitoring should indicate water quality improvement within 5 to 10 years. Additional survey and monitoring data is needed for the Connecticut River main stem before response objectives can be quantified.

(F) Response monitoring: The initial response will be monitored with qualitative surveying. As mussel populations increase in size, quantitative methods will be used (Strayer and Smith 2003).

(G) Implementation: In 2000 the NHDES helped establish the New Hampshire River Restoration Task Force with the objective, in part, of exploring possible dam removal in order to restore rivers. The Task Force includes state and federal agencies, conservation organizations, towns, and other interest groups. The Task Force facilitated the removal of two dams on the Ashuelot River: the McGoldrick Dam in Hinsdale in 2001 and the Winchester Dam in 2002. Two dams remain: the Homestead Woolen Mill Dam in West

Swanzey and the Fiske Mill Dam in Hinsdale. The Homestead Woolen Mill Dam is under consideration for removal; however, the Fiske Mill Dam was under consideration for removal but was purchased recently for hydroelectric power use (Loiselle, River Restoration Coordinator, NHDES). In addition, The Nature Conservancy has begun implementing a land conservation plan for the Ashuelot River (Zankel, 2004).

(H) Feasibility: Dam removal projects are feasible. However, the Town of Swanzey has not yet decided to remove the Homestead Dam. In 1998 the owner of Homestead Woolen Mills applied to breach the dam, though he is now willing to convey ownership to the town. Issues that may favor the town taking ownership of the dam include the historic covered bridge just upstream of the dam that may suffer scour damage without the dam and the influence of decreased water levels on fire department access. The selectmen are soliciting comment prior to an August 2005 meeting to reach a consensus. A final decision may require a warrant article for town meeting, March 2006 (Sara Carbonneau, Swanzey Town Planner, personal communication).

The Nature Conservancy's land protection initiative will begin in 2006 (Aldridge, The Nature Conservancy, personal communication). In addition, The Nature Conservancy's Connecticut River Program, in partnership with the United States Geological Survey, the University of Massachusetts, and Dartmouth College and the Army Corps of Engineers will hire a postdoctoral student to assess and implement trial flow regimes and determine their ecological responses in the Ashuelot River (Lutz, Director, The Connecticut River Program, The Nature Conservancy, personal communication).

4.2 Conservation action research:

In addition to removal of McGoldrick and Winchester Dams on the Ashuelot River, the Cuddebackville Dam on the Neversink River, New York, was successfully removed without apparent impairment of the downstream dwarf wedgemussel population (Strayer, Institute for Ecosystem Studies, Millbrook, New York, personal communication).

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5.1 Literature

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Zankel, M. 2004. A land conservation plan for the Ashuelot River Watershed. The Nature Conservancy, Concord, New Hampshire.

SPECIES PROFILE

Eastern Pondmussel

Ligumia nasuta

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S1
Author: Barry J. Wicklow, Department of Biology, Saint Anselm College

Element 1: Distribution and habitat

1.1 Habitat Description

Eastern pondmussels inhabit ponds, lakes, and the low velocity segments of streams and rivers. They are often found in fine sands and other soft sediments (Strayer and Jirka 1997). Mussels are suspension feeders, subsisting on phytoplankton, bacteria, fine particulate matter, and dissolved organic matter (Strayer 2004).

Unionid mussels have complex life cycles. Larvae called glochidia must attach and encyst on a host species – usually a fish – to complete development disperse. Little is known about the reproductive biology of the Eastern pondmussel, and host fish species for glochidia have not been determined. They are long-term brooders, spawning in summer, then releasing glochidia the following spring or summer.

Mantle displays in eastern pondmussel function to attract hosts; papillae line the mantle edge, rhythmic movements of which elicit attacks by potential host fish (Corey 2003). Glochidia are discharged during the attack.

1.2 Justification

Freshwater mussels are the most imperiled fauna in North America, having suffered steep declines in diversity, abundance, and distribution within the last 200 years (Richter et al. 1997, Master et al. 2000, Lydeard et al. 2004). The Eastern pondmussel is distributed from Ontario, Canada, along the Atlantic coast to Virginia and west into Pennsylvania and New York. It is stable and abundant in many locations and is expanding its range into the Allegheny basin in New York (Strayer and Jirka 1997). Nevertheless, the Freshwater Mussel Subcommittee of the American Fisheries Society's Endangered Species Committee listed it as a species of special concern (Williams et al. 1992), and the Northeast Endangered Species and Wildlife Diversity Technical Committee listed it as a species of regional conservation concern (Therres 1999). It is listed as threatened in New Jersey and endangered in Delaware. In Maine, Massachusetts, and Connecticut it is listed as Special Concern (Nedeau et al. 2000, Nedeau and Victoria 2002). The Eastern pondmussel was ranked as a priority candidate for status under the Committee on the Status of Endangered Wildlife in Canada, COSEWIC (Metcalfe-Smith 1998).

In New Hampshire, Eastern pondmussels are found in only 4 ponds in the southeast part of the state. Zebra mussel, *Dreissena polymorpha*, introduction is a critical threat to the Eastern pondmussel. Zebra mussels have decimated unionid mussels in ponds, lakes, and rivers.

1.3 Protection and Regulatory Status

- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats, including the banks of rivers, streams, and lakes.
- The Shoreland Protection Act (NHDES, RSA 483-B) limits the amount of tree removal and other activities within 250 ft of major rivers and requires a primary structure setback of at least 50 ft.
- Local regulations and zoning vary considerably.

1.4 Population and habitat distribution

The only extant populations of Eastern pondmussels occur in 4 locations in the coastal watershed: Golden Brook near the outflow of Simpson Pond in Windham, Wash Pond in Hampstead, Great Pond in Kingston, and Powwow Pond in East Kingston (Clench and Russell 1938, Master 1990, Cutko and Johnson 1992). There is 1 historic record for Keene in the Connecticut River watershed (Clench and Turner 1938). Eastern pondmussels were not found during surveys of the Ashuelot River from Keene to Hinsdale between 2001 and 2004 (Nedeau and Werle 2003). However, it is found in the Connecticut River watershed in Massachusetts and Connecticut, and recently in a Connecticut River tributary as far north as Whately, Massachusetts (von Oettingen, USFWS, personal communication).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Known occupied lakes and rivers are mapped in the Natural Heritage Bureau database. Future mapping efforts should identify suitable habitat that has not been surveyed.

1.7 Sources of Information

Information on the life history, habitat requirements, and distribution of Eastern pondmussel was obtained from the scientific literature, unpublished reports, databases, and expert consultation.

1.8 Extent and Quality of Data

Information of the Eastern pondmussel in New Hampshire is sparse, and data are limited to occurrence locations: Wash pond Hampstead, 9 living individuals, 1992; Golden Brook near the outflow of Simpson Pond, Windham, 1 individual, 1990; Powwow Pond, East Kingston, 1 individual, 2004; Great pond, Kingston, 1 live individual in 2 hours of searching on the southwestern shore, 1992. In 2000, on the eastern shore of Great Pond several dozen individuals were observed embedded in fine sand (von Oettingen, USFWS, personal observations).

1.9 Distributional research

All current occurrence locations need to be resurveyed. Larger populations should be monitored using quantitative, statistically valid methods.

Element 2: Species/Habitat Condition

2.1 Scale

Each pond with an existing population of Eastern pondmussel should be treated as a conservation management unit.

2.2 Relative health of populations

Information that is needed to assess relative abundance, size, density, or recruitment of Eastern pondmussel populations does not exist. Based on incomplete surveys and observations, it appears that Great Pond in Kingston supports a viable population. It is possible that Eastern pondmussel will be found in other coastal watershed ponds and streams as well as in the Connecticut River watershed.

2.3 Population management status

There is no population management of the Eastern pondmussel. Additionally survey information is needed in order to identify potential conservation opportunities.

2.4 Habitat patch protection status

Very little habitat information exists. Most Eastern pondmussel populations or site occurrences have not been assessed in over 10 years. Ecological attributes have not been measured, and research is needed to determine population size, density, and recruitment and to assess habitat.

2.5 Habitat patch protection status

Information needed to assess the quality of habitats is sparse. The Department of Environmental Service Limnology Bureau monitors water quality at all occurrence locations.

2.6 Habitat management status

There are no habitat management efforts for Eastern pondmussel populations.

2.7 Sources of information

Information was obtained from reports, database, and consultation with experts.

2.8 Extent and quality of data

Data on the condition of Eastern pondmussel populations do not exist. Department of Environmental Service water quality data meet United States Environmental Protection Agency standards.

2.9 Condition assessment research

Ponds with Eastern pondmussel occurrences need to be resurveyed to include all areas of potential habitat. In addition to resurveys of occurrence sites, surveys of pond outflow streams as well as nearby ponds and lakes are needed. Powwow River, which drains both Great Pond and Powwow Pond, is a priority stream. Other priority sites are Country pond, Kingston; Long Pond, Danville; Island Pond, Hampstead/ Derry; and Philips and Angle Ponds, Sandown. Populations of Eastern pondmussel need to be monitored using techniques that indicate density, recruitment, and population trends (Strayer and Smith 2003, Villella et al. 2004). Research to determine life history traits and host fish species is essential.

Element 3: Species and habitat threat assessment

3.1.1 Introduced Species

(A) Exposure Pathway
Adult zebra mussels are transported from basin to basin while attached to boats, and larvae may be transported in bilge and bait bucket water. Zebra mussels compete with native freshwater mussels for food and may reduce food concentration to levels that cannot support native species. Larvae of zebra mussels require calcium levels between 8 20 ppm in order to complete development, well within the range of calcium levels found, for example, in the Connecticut River.

(B) Evidence
After their initial discovery in Lake Saint Clare in 1988, zebra mussels quickly spread throughout many regions of the United States and parts of Canada. Their effect on the decline of freshwater mussels in the Hudson River is well documented (Caraco et al. 1997, Strayer 1999), and zebra mussels have severely affected mussels in Lake Champlain in Vermont. Recently a zebra mussel was detected on a boat in a boatyard at Lake Winnipesaukee, underscoring the need to intensify boat ramp surveys, particularly at high-use boating areas at all Eastern pondmussel locations and neighboring ponds.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure pathway
Riparian corridors and adjacent lands are being rapidly developed in New Hampshire. Lakeshores are highly valued for the recreation potential they offer, and lakeside development, docks, and motorized boat traffic degrade habitat, lower water quality, and increase pollution.

(B) Evidence
Habitat destruction, pollution, and water degradation are considered the most likely causes for the decline of freshwater mussels (Neves 1997, Strayer et al. 2004). The east and south shores of Great Pond are developed, and development continues on the southwest shore of Powwow Pond an around most of Wash Pond. Additional on-site threat evidence needs to be gathered.

3.1.3 Non-Point Source Pollution

(A) Exposure Pathway
Runoff from municipalities, industrial waste, sewage outfalls, golf courses, and poorly managed agricultural and silvicultural lands degrades water and leads to sedimentation and organic pollution. As rapid development increases, impervious surfaces increase the volume and velocity of runoff, causing erosion, sedimentation, and toxic pollution in streams and rivers. Riparian vegetation is critical in retarding these effects.

Mussels are sensitive to chronic and acute exposure to heavy metals introduced through runoff and

atmospheric deposition as well as to toxins, such as chlorine and ammonia (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are considered the life stages most sensitive to pollutants. Juveniles burrow into and feed within the sediments; adult mussels may also deposit feed. Low sediment pore-water oxygen and high sediment levels of toxins put infaunal juveniles at risk. Hence, sediments may represent a major contamination pathway for mussels (Newton et al. 2003, Poole and Downing 2004).

(B) Evidence
The effect of acute pollution on freshwater mussels is well-documented (Neves et al. 1997), and chemical and agricultural waste spills cause direct mussel mortality. For instance, hundreds of mussels, some state and federally listed, were killed by waste runoff from a small farm in the Connecticut River watershed (USFWS 2002). The most widely reported sources of pollution are poor land use practices (Neves et al. 1997, Poole and Downing 2004). The effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are much more sensitive to toxins than glochidia (Cherry et al. 2005).

3.2 Sources of Information

Information was gathered from the scientific literature, reports, and consultation with experts

3.3 Extent and quality of data

Threats have not been documented specifically for Eastern pondmussels and their habitat, though the threats to other unionid mussels are well documented. The synergistic and long-term effect of the multiple kinds of chronic stresses on freshwater mussels is unknown.

3.4 Threat assessment research

Mussel surveys and additional land use data are needed in order to assess the potential for future development at Eastern pondmussel occurrence locations.

Element 4: Conservation Actions

4.1.1 Restoration and management

It is difficult to define specific conservation actions without information about distribution and abundance, reproduction, and life history of Eastern pondmussels. In general however, efforts are needed to protect riparian buffers, monitor pollution runoff from agricultural, residential, and commercial sources, intensify zebra mussel boat surveys, and further educate resident boat owners of the impacts of zebra mussel introduction.

Element 5: References

5.1 Literature:

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SPECIES PROFILE

Frosted Elfin

Callophrys (Incisalia) irus

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G3
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The habitat of the frosted elfin in New Hampshire is identical to that of the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*): pine barrens with ample patches of blue lupine (*Lupinus perennis*), the only larval host plant (Schweitzer 1992, Swengel 1996). Whereas Karner blue butterfly larvae consume the leaves, frosted elfin larvae typically consume flowers and seedpods of the blue lupine (Swengel 1996). Flight period of the frosted elfin is from May to June, coinciding with the first flight of the Karner blue butterfly. Frosted elfin eggs are laid among the flower stalks and buds of the blue lupine (Swengel 1996). Larvae pupate underground and remain there until the following spring (Schwitzer 1992, Swengel 1996). For a detailed habitat description, see the Karner blue butterfly and pine barrens profiles.

1.2 Justification

The frosted elfin, along with the Karner blue butterfly, is an indicator of the health of the pine barrens habitat. As habitat goes unmanaged and reverts to a closed canopy system, the frosted elfin will die out. Frosted elfins are highly susceptible to population declines, which are a product of host plant specificity, environmental change, low dispersal rates, and small subpopulation size (Cushman and Murphy 1993), as well as cannibalism among larva. These factors are magnified by a severe loss of habitat. Nearly 90% of historic pine barrens communities along the Merrimack River have been lost, leaving a mere 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994). Because frosted elfin eggs are laid among the flowers of the blue lupine, they are vulnerable to early summer mowing and incidental ingestion by herbivorous species.

1.3 Protection and Regulatory Status

The frosted elfin is listed as Endangered under the New Hampshire State Endangered Species Act. Blue lupine is listed as threatened in New Hampshire under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution

The range of the frosted elfin extends from northern New England across to New York, Ohio, Indiana, Michigan, and Wisconsin, and along the eastern seaboard with pockets in southern New Jersey, eastern Maryland, West Virginia, South Carolina, and northern Florida (Swengel 1986, Schwitzer 1992, NatureServe 2005). The frosted elfin is believed to have been extirpated in Ontario, Maine, and Illinois (NatureServe 2005).

In New Hampshire, populations of the frosted elfin currently occur only in the Concord Pine Barrens, but there are records from the towns of Webster and Durham from the early 1900s (NHNHB 2005). Numbers at the Concord Pine Barrens are low. Between 10 and 30 frosted elfin are observed each year during lepidopteran surveys conducted at the Concord Pine Barrens (Chandler 2002, NHFG). For details regarding habitat distribution, see Karner blue butterfly species profile and pine barrens habitat profile.

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile and pine barrens habitat profile.

1.7 Sources of Information

Sources of information include field reports, agency data, scientific journal articles, and element occurrence databases.

1.8 Extent and Quality of Data

Lepidoptera surveys are conducted annually at the Concord Pine Barrens, and frosted elfin have been seen every year. Other areas where pine barrens habitat occurs have not been surveyed for frosted elfin.

1.9 Distribution Research

Survey other remnant pine barrens sites along the Merrimack River in Manchester and Bedford for frosted elfin. Historic frosted elfin observations in Webster and Durham warrant further investigation.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature:

Chandler, D.S. 2002. New Hampshire Army National Guard butterfly and moth survey, 2001 final report. University of New Hampshire. Durham, New Hampshire, USA.

Cushman, J.H. and D.D. Murphy. 1993. Susceptibility of Lycaenid butterflies to endangerment. Wings 17:16-21.

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Schweitzer, D.F. 1992. *Incisalia irus* revisited: a response to Reverend Ronald Gatrelle. News of the Lepidopterists Society 4:69-70.

Swengel, A.B. 1996. Observations of *Incisalia irus* (Lepidoptera: Lycaenidae) in Central Wisconsin 1988-95. The Great Lakes Entomologist 29: 47-62.

5.2 Data Sources

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New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Indigo Duskywing
Erynnis baptisiae

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S1
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The wild indigo duskywing (*Erynnis baptisiae*) is an associate of the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*) and lives in the grassy openings of pine barrens, under powerlines, and along roadsides where crown vetch (*Coronilla varia*) grows (Schweitzer 1992, Glassberg 1993, Mello 1998). Wild indigo (*Baptisia tinctoria*) and blue lupine (*Lupinus perennis*) were historically the predominant larval host plants, but as these plants have declined in number, wild indigo duskywing began to feed on crown vetch (Schweitzer 1992, Glassberg 1993, Mello 1998). Adult wild indigo duskywings fly from late April to early June and again in July and August (Scott 1986). Eggs are laid singly on the host plant, and the second brood larvae overwinter (Scott 1986). For a detailed habitat description, see Karner blue butterfly species profile and the Pine Barrens habitat profile.

1.2 Justification

The wild indigo duskywing, along with the Karner blue butterfly, frosted elfin (*Callophrys* [*Incisalia*] *irus*), and Persius duskywing (*Erynnis persius persius*), is an indicator of the health of the pine barrens habitat. It is in severe decline in the eastern part of range due to habitat loss and fire suppression (Schweitzer 1992); nearly 90% of historic pitch pine-scrub oak barren communities along the Merrimack River have been lost, leaving a mere 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994).

With the decline of wild indigo and blue lupine, the wild indigo duskywing became uncommon in the eastern part of its range. It has since adapted to utilize crown vetch as its larval host plant, and is rapidly colonizing areas where crown vetch is planted (along roadways and airports). Wild indigo duskywing is extremely difficult to identify in the field due to its similarity to other members of the *Erynnis* genus, and therefore there is some uncertainty about larval food plants and specific habitat requirements (Schweitzer 1992).

1.3 Protection and Regulatory Status

Although the wild indigo duskywing is not state or federally listed, it is protected as an associate of blue lupine, which is listed as threatened in New Hampshire and protected under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution:

The wild indigo duskywing was uncommon until larvae became adapted to crown vetch. It is now widespread and is expanding its range from New England and extreme southern Ontario southward to the Gulf Coast states excluding Florida, and westward to Minnesota, central Nebraska, and south central Texas (Opler and Malikul 1992, Glassberg 1993).

In New Hampshire, the wild indigo duskywing was observed in 1986 under the power lines along Merrill Hill in Hudson (New Hampshire Natural Heritage Bureau 2005). Wild indigo duskywings have also been positively identified in the Concord pine barrens during lepidopteran surveys conducted there in 1998 and 2001 (Mello 1998, Chandler 2001).

1.5 Town Distribution Map
A map is provided.

1.6 Habitat Map
N/A

1.7 Sources of Information

Sources of information include field reports, field guides, and element occurrence databases.

1.8 Extent and Quality of Data

There are only two documented occurrences of the wild indigo duskywing in New Hampshire (Mello 1998, Chandler 2001, NHNHB 2005). Since this species is very similar to other members of the *Erynnis* genus, proper identification in the field is challenging.

1.9 Distribution Research

Before initiating surveys for this species, voucher specimens are needed and distinguishing characteristics should be noted.

Elements 2-4: *See the Karner Blue Butterfly and the Pine Barrens profiles.*

Element 5: References

5.1 Literature

Chandler, D.S. 2001. New Hampshire Army National Guard butterfly and moth survey, Concord, New Hampshire. University of New Hampshire, Durham, New Hampshire, USA.

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5.2 Data Sources

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SPECIES PROFILE

Karner Blue Butterfly

Lycaeides melissa samuelis

Federal Listing: Endangered
State Listing: Endangered
Global Rank: G5T2
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Karner blue butterflies inhabit pine barrens, an early-successional community composed of 4 distinct vegetative strata: herbaceous, heath, scrub, and canopy. Within the scrub and canopy strata, shade-providing pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) dominate. The lower strata include grasses, vascular plants, and heath. Throughout these layers little bluestem (*Schizachyrium scoparium*) and big bluestem (*Andropogon gerardii*) are the principle grass species, affording roost sites and predator protection by attendant ants. New Jersey tea (*Ceanothus americanus*), spreading dogbane (*Apocynum androsaemifolium*), lowbush blueberry (*Vaccinium angustifolium*), and huckleberry (*Gaylussacia bacata*), as well as state threatened blue lupine (*Lupinus perennis*), blunt-leaved milkweed (*Asclepias amplexicaulis*), and golden heather (*Hudsonia ericoides*) comprise the majority of the herbaceous and heath layer and provide a critical source of nectar (United States Fish and Wildlife Service 2003). Spatially, these strata form a heterogeneous matrix of open, sub-canopied, and canopied habitat patches across the landscape, which in turn create a gradient of light intensities and thermal conditions necessary for habitat-specific behaviors. Temporally, this structural diversity is in constant flux, a process maintained by periodic disturbance, namely fire. Currently, Karner blue butterflies are restricted to fragmented pine barren remnants, highway and powerline rights-of-way, airports, military camps, and gaps in forest stands that support their obligate host plant, blue lupine (USFWS 2003).

1.2 Justification

Karner blue butterflies, as well as other members of the family Lycaenidae, are highly susceptible to environmental changes and population declines, which are a product of their host plant specificity, symbiotic relationship with attendant ants, low vagility, and small subpopulation size (Cushman and Murphy 1993, Grundel et al. 1999). Additionally, Karner blue butterflies have behavior-specific habitat requirements, where canopy heterogeneity is essential for successful mating, breeding, oviposition, and nectaring (Grundel et al. 1998b). Such specialization gives Karner blue butterflies the designation of an umbrella species. Not only do they serve as an indicator of habitat quality, but management for their stringent habitat requirements meets the needs of other state endangered and threatened wildlife species as well, thereby maximizing overall biodiversity throughout the community. Associated species include frosted elfins (*Incisalia irus*) and Persius duskywing skippers (*Erynnis persius persius*) whose larvae also feed solely on wild lupine, as well as pine barrens zanclognatha moths (*Zanclognatha martha*), eastern hognose snakes (*Heterodon platirhinos*), grasshopper sparrows (*Ammodramus savannarum*), and common nighthawks (*Chordeiles minor*).

The limiting factors for Karner blue butterflies have been compounded by a severe loss of habitat. Nearly 90% of historic pine barren communities along the Merrimack River have been lost (Helmbolt and Amaral 1994). Without enough suitable habitats to support a viable population, Karner blue butterflies became extirpated in New Hampshire in 2000 (Amaral 2000), and were subsequently reintroduced.

1.3 Protection and Regulatory Status

- National Plant Protection Act: promotes the preservation of blue lupine, blunt-leaved milkweed, and golden heather (*Hudsonia ericoides*) on state lands, but provides no protection on private property (VanLuven 1994)
- RSA 217-A, Native Plant Protection Act: blue lupine is threatened in New Hampshire and thus cannot be disturbed on public land

1.4 Population and Habitat Distribution

The distribution of Karner blue butterflies is largely dependant on the availability of blue lupine, the larval food source, and preferred native nectar sources (Schultz and Dlugosch 1999). These plants occur in pine barrens habitat. These pine barren communities occur primarily on glacially deposited sand, shale, and serpentine soil types in parts of eastern North America (Sutton 1925). In New Hampshire, this community type once spanned the Merrimack River valley from Canterbury to Nashua, occupying Windsor sandy loams and Hinckley cobbly sandy loams (VanLuven 1994). Today, only one site in New Hampshire, the Concord pine barrens, supports a population of Karner blue butterflies. Prior to their extirpation in 2000, Karner blue butterflies inhabited 2 sites within the 227 ha (563 ac) of the Concord Pine Barrens (Schweitzer 1983). A reintroduction program has since been initiated to restore viable metapopulations of Karner blue butterflies throughout their range.

Locally, the Concord population represents the easternmost extent of this species' distribution and is separated from the nearest population in New York by over 225 km (140 mi) (Helmbolt and Amaral 1994). Regionally, Karner blue butterflies formerly occurred in a band extending across 12 states from Minnesota to Maine and in the province of Ontario, Canada, but now only occur in the 7 states of Minnesota, Wisconsin, Indiana, Michigan, New York, New Hampshire, and Ohio (USFWS 2003).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Incomplete

1.7 Sources of Information

Information on Karner blue butterfly habitat, population distribution, and status was collected from habitat and recovery conservation plans, technical field reports, agency data, and scientific journals.

1.8 Extent and Quality of Data

The Karner blue butterfly is one of the most intensely managed and monitored species in New Hampshire. The Concord pine barrens have been monitored for Karner blue butterflies for at least the past 20 years and results are well documented.

1.9 Distribution Research

A captive rearing and reintroduction program initiated by TNC in 1992 and then continued under the direction of NHFG in 2000 has worked towards restoring viable metapopulations of Karner blue butterflies throughout their historic range. Dispersal and colonization rates have been monitored to adequately assess habitat utilization, movement patterns, and reintroduction success (Fuller et al. 2003). Current distribution data should be acquired, and historic observations in Webster, Manchester, Milford, and south Merrimack warrant further investigation.

Element 2: Species/Habitat Condition

2.1 Scale

Conservation Zones as delineated under the Concord Municipal Airport Development and Conservation Management Agreement (2000) will be used as the conservation-planning unit for Karner blue butterflies. Outlying historic populations and remnant habitat patches may be treated independently.

2.2 Relative Health of Populations

Historically, Karner blue butterflies occurred in 5 sites in New Hampshire: Milford (1880), Merrimack (1880), Webster (1896), Manchester (no date), and Concord (New Hampshire Natural Heritage Bureau 2005). Of these sites, the Concord pine barrens supported the last remaining native population in the state. In 1980, an estimated 3,700 butterflies occu-

pied this area but the population was soon reduced to less than 50 by 1994 (Schweitzer 1983, Peteroy 1998). Extirpation followed in 2001, resulting in the initiation of a captive rearing and reintroduction program (USFWS 2003). Translocation success is difficult to measure in the short term, but survey results suggest that more than 100 Karner blue butterflies completed their life cycles in the wild during 2003. The New Hampshire population will be designated as fully recovered upon the establishment of one metapopulation of at least 1,500 first brood or second brood adults that is sustained for a minimum of 5 years (USFWS 2003).

2.3 Population Management Status

Release of translocated captive-reared butterflies has been underway at Concord Municipal Airport since 2001 (USFWS 2003). Habitat restoration and reserve design has been developed in a metapopulation context, with intensive restoration sites connected by managed corridors (Fuller et al. 2003).

2.4 Relative Quality of Habitat Patches

The minimum habitat requirements of Karner blue butterflies include: 1) suitable habitat and occupied sites greater than 0.25 ha, 2) small areas (0.25-5 ha [) having at least 500 blue lupine stems per 0.4 ha or 810 blue lupine stems per 0.4 ha, 3) larger habitat areas (>5 ha) having at least 0.1 blue lupine stem per m^2 or 405 blue lupine stems per 0.4 ha, 4) available nectar for each adult butterfly flight period, and 5) habitat heterogeneity (USFWS 2003). Based on these criteria, the South Airport Conservation Zone (144 ha) and the North Airport Conservation Zone (24 ha), both of which support the largest population of blue lupine and nectar plants, are considered the highest quality and most critical habitat patches (VanLuven 1994).

2.5 Habitat Patch Protection Status

Approximately 227 ha of the remnant Concord pine barrens are protected through the Concord Municipal Airport Development and Conservation Management Agreement (2000). Conservation Zones have been established on the 227 ha of airport land, which will be managed to enhance and restore critical habitat for Karner blue butterflies as well as a suite of other rare species. The land is owned by the city of Concord, with an 11 ha conservation easement granted to the USFWS. The conservation easement is open to the public but wheeled vehicles are forbidden. The 1 ha left of the historic main site, located along a powerline right-of-way, is privately owned, and maintained by Public Service of New Hampshire.

2.6 Habitat Management Status

Current habitat management and restoration techniques used in the Conservation Zones include native plant propagation, vegetation management using specialized mowers and feller bunchers, and prescribed fire. These techniques are used to create sandy and herbaceous openings within a matrix of heath, scrub-shrublands, and woodlands. Habitat monitoring is completed before and after management implementation. The goal is to create a shifting mix of native grassland, shrubland, and woodland features (Fuller et al. 2003).

2.7 Sources of Information

Information on habitat protection and management was obtained from Concord pine barrens recovery and management plans.

2.8 Extent and Quality of Data

The Karner blue butterfly is one of the most intensely monitored and studied species in New Hampshire. The Concord pine barrens have been monitored for Karner blue butterflies for at least the past 20 years. Blue lupine has been mapped and/or monitored for almost 10 years.

2.9 Condition Assessment Research

Habitat quality and restoration feasibility of the Goldstar Farms easement in Canterbury, New Hampshire needs to be evaluated. Further investigation of historic occurrence records associated with this location is needed.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
The properties associated with pine barrens communities (i.e., sandy soils, high stability, high permeability, low compaction, and ease of excavation) make them optimal for development. Both commercial and residential developments contribute to habitat reduction and fragmentation. As habitat is lost and becomes more fragmented, colonization of the remaining habitat patches becomes increasingly difficult. Population reduction and extirpation or extinction is the ultimate result if habitat conditions are not improved. Karner blue butterfly populations fluctuate widely. As local populations become extinct, it is improbable that recolonization will occur.

(B) Evidence
Karner blue butterflies have a positive association with habitat areas that are large, have high light intensity, and are recently managed (Smallidge et al. 1996). Extensive commercial and residential development of the Concord pine barrens has severely reduced habitat for Karner blue butterflies. About 5-10% of the original Concord pine barrens remains today, and virtually all pine barrens south of Concord have been lost (Helmbolt and Amaral 1994).

3.1.2 Scarcity (Natural Variation on Reproductive Success)

(A) Exposure Pathway
Cool/wet and hot/dry conditions can delay or accelerate Karner blue butterfly larval hatching and development, reduce adult flight times, mating opportunities, and oviposition rates, and upset host plant-larvae synchronicity (Schweitzer 1989). Natural variation in weather may result in wide population fluctuations. Added to depressed population size, wide population fluctuations may result in local extinction.

(B) Evidence
Monitoring trends for northeastern populations show that annually, Karner blue butterfly populations fluctuate widely (S. Fuller, NHFG, unpublished data, K. O'Brien, New York Endangered Species Program, unpublished data). Captive rearing programs at the Toledo Zoo in Ohio and Concord, New Hampshire report that mating and oviposition are related to environmental factors (New Hampshire Fish and Game unpublished data, Toledo Zoo unpublished data). The especially cool wet spring during the 2003 Karner blue butterfly season in New York resulted in a population crash of first brood adults (K. O'Brien, New York Endangered Species Program, personal communication).

3.1.3 Development (Dispersal Barriers)

(A) Exposure Pathway
Development is occurring rapidly in the area surrounding the Concord Municipal Airport. Karner blue butterflies utilize grassy openings, but paved areas, buildings, and closed-canopy forest stands are increasingly dominant on the landscape. As a result, dispersal is limited, even when high quality habitat is restored.
Land managers face the challenge of not only maintaining quality habitat, but also ensuring that habitat patches are situated over the landscape in a manner that allows movement and genetic exchange among patches (Grundel et al. 1999). The presence of nectar sources between sites can enhance inter-site dispersal (King 1998b).

(B) Evidence
The implications of disrupted metapopulation processes are well documented in the literature for Lepidoptera. Dispersal between subpopulations may be depressed in metapopulations fragmented by paved areas, limiting the establishment of new colonies and viability of existing ones. Karner blue butterflies are less likely to fly over paved areas, around buildings, or through closed-canopy forest stands (King 1998a, Grundel et al. 1999, Fuller, unpublished data). Karner blue butterflies may become 'stuck' at the edges of paved areas. Shopping centers, an industrial park, and the Concord Municipal Airport fragment remnant habitat patches.

3.1.4 Introduced Species (Introduced Insects)

(A) Exposure Pathway
Biological controls for horticultural pests may be

detrimental to Karner blue butterfly populations via multiple pathways. Ladybird beetles (*Coccinella septempunctata*) and parasitic wasps that are used to control aphids may prey on Karner blue butterfly larvae. Aphids feed on the fluids of blue lupine, causing the plants to wilt and become unsuitable food for Karner blue larvae.

(B) Evidence
Koch et al. (2003) observed that Asian lady beetles (*Harmonia axyridis*) that are used for biological control of aphid species were a significant predator of immature monarch butterflies (*Danaus plexippus*). Escaped parasitic wasps and flies have been known to utilize native lepidopteran hosts.

3.1.5 Altered Natural Disturbance Regime (Natural Succession)

(A) Exposure Pathway
Suppression of wildfires can lead to succession of pine barrens communities to closed-canopy forest communities, eliminating suitable habitat for blue lupine and Karner blue butterflies. A lack of a regular mild fire regime may result in fuel loading. In a fuel-loaded system, fires may reach a higher intensity than fires in a well-maintained system, which would impact the remnant habitat patches more broadly and severely and potentially lead to direct mortality of Karner blue butterfly populations.

(B) Evidence
Before intense management practices were initiated at the Concord pine barrens in 1994, the area had reverted to closed-canopy pine forests and woodlands, mixed scrub thickets, and disturbed grassy openings (VanLuven 1994). Karner blue butterflies prefer early to mid-successional habitats whose suitability can deteriorate in a few years in the absence of disturbance (Grundel et al. 1999). Woodland management policies that do not promote opening of canopies often negatively affect Karner blue butterfly habitat (Grundel et al. 1998a). Increased canopy cover is a major factor implicated in the decline of Karner blue butterflies at many locales (Grundel et al. 1998b).

3.1.6 Predation and Herbivory

(A) Exposure Pathway
Access to protected Karner blue butterfly habitat is limited for hunters and predators. Heavy browsing of blue lupine plants by white-tailed deer (*Odocoileus virginianus*) and woodchuck (*Marmota monax*) could severely reduce blue lupine populations and result in Karner blue butterfly mortality by accidental ingestion of eggs and larvae.

(B) Evidence
Approximately 80% of the blue lupine plants that were planted in 2 restoration plots (including a captive breeding release site) had their flower stalks removed by grazing during 2004 (NHFG, unpublished data). Significant browse is common in blue lupine populations (USFWS 2003).

3.1.6 Altered Natural Disturbance Regime (Mowing)

(A) Exposure Pathway
The majority of extant Karner blue butterfly habitat has been maintained inadvertently via non-conservation land uses, such as maintenance of powerline rights-of way and airport runway safety zones. The optimal window (April-August) for mechanical vegetation management practices such as mowing coincides with the blue lupine growing season and sensitive phases of the Karner blue butterfly life cycle. Mowing during this period may cause blue lupine mortality, reduce seed production, reduce forage for emerging larvae, dislodge eggs and larvae from hosts, or cause direct mortality of any life stage. There is currently no established forum for communication between wildlife managers and other land managers to reduce these impacts.

(B) Evidence
Extensive mowing occurs on the Concord Municipal Airport to manage the runway safety and approach areas. Mowing also occurs along fence-lines for security purposes. In spite of regulatory efforts, mowing and other non-compatible land-uses have inadvertently occurred. It is difficult to document direct mortality because plant cuttings (blue lupine) can easily be spread far from established plants by rotating blades.

3.2 Sources of Information

Information on threats was taken from the Karner blue butterfly recovery plan, habitat conservation plan, scientific journal articles, and personal communications and observations.

3.3 Extent and Quality of Data

Threats to Karner blue butterflies and their habitat are well documented in management and conservation plans. While there may be little evidence documenting the actual occurrence of certain threats, the potential for the threat to occur is well documented.

3.4 Threat Assessment Research

- Identify threatening introduced insect species
- Assess impact of herbivory on butterflies
- Evaluate impacts of maintenance mowing on Karner blue butterflies

Element 4: Conservation Actions

4.1.1 Habitat Management

(A) List of Direct Threats Affected: Habitat loss, succession, and barriers to dispersal

(B) Justification
Habitat management will increase the availability of suitable habitat in areas currently or potentially occupied by Karner blue butterflies by converting closed-canopy stands to an early-successional structure. Standard habitat management techniques including forestry, fire, and herbicide have well-documented efficacy in reducing the cover of canopy-forming, shade-tolerant, and fire-sensitive species. The technique, frequency, and intensity of management will be prescribed to increase light reaching the herbaceous strata, to create soil disturbances, and to connect existing blue lupine populations. Open-canopy corridors will offset failed dispersal and foraging in impermeable and/or unsuitable landscapes, such as the edges of runways and roads.

Blue lupine and early-successional nectar plant species abundances increase in response to a broad range of vegetation management techniques (Smallidge et al. 1996). Management creates areas of open or semi-open habitat that provide a range of light intensity and diverse vegetation, all necessary for successful dispersal, foraging, and oviposition (Grundel 1998a). Habitat heterogeneity satisfies microhabitat needs and moderates the impact of large-scale environmental events (USFWS 2003). Habitat management also provides connectivity among resource-rich habitat patches, increasing dispersal rates, colonization, and overall suitable habitat area.

Karner blue butterfly populations have persisted in landscapes of similar structure and lesser size than the area managed in Concord. Habitat management is necessary to prevent the loss of protected habitat to succession, but is not adequate to secure unprotected remnants and buffer existing conservation land from development.

Restorative management intensity is high in the short-term, but can be reduced to a sustainable maintenance level in the long-term. Depending upon the intensity of management, beneficial responses can be observed in 0-3 years, and maintained with management on a 5-10 year rotation.

The densities of blue lupine and other early successional plants can be controlled and maximized by adjusting the frequency and intensity of habitat management to modify current densities of canopy species and scrub oak. The prescription may be adapted to guide management in new habitat areas.

(C) Conservation Performance Objective
The habitat management performance objective is to create a matrix of interconnected grasslands, shrublands, and woodlands by manipulating the densities of woody species in key vegetative strata. Management schedules and target levels for management units by strata and species are described in Fuller et al. (2003). Progress toward target levels (i.e., reduction in canopy and shrub strata) will indicate the performance of habitat management.

(D) Performance Monitoring
Densities of woody species will be monitored as prescribed in Fuller et al. (2003) prior to implementation of management and in subsequent years.

(E) Ecological Response Objective
The habitat management response objective is to increase the densities of blue lupine, key nectar plant species, and the proportion of early successional veg-

etative strata. Target levels for management units by strata and species are described in Fuller et al. (2003). Progress toward target levels (i.e., increase in blue lupine and nectar plant species densities and in proportion to sand, herbaceous, and heath strata) will indicate a beneficial response to habitat management.

(F) Response Monitoring
The density of blue lupine and richness of other key habitat plants will be monitored as prescribed in Fuller et al. (2003) prior to implementation of management and in subsequent years.

(G) Implementation
NHFG, NHDRED, the New Hampshire Army National Guard, USFWS, the Federal Aviation Administration, and the City of Concord will cooperate to implement habitat management as per the Concord Municipal Airport Development and Conservation Management Agreement (2000), the management plan (Fuller et al., 2003), and under the guidance of the management team.

(H) Feasibility
The partnership described has successfully implemented habitat management. Future feasibility is limited only by funding, which is secure through 2012.

4.1.2 Education and Outreach

(A) List of Direct Threats Affected
Habitat loss, barriers to dispersal, succession, mowing during critical periods

(B) Justification
Engaging the public to propagate habitat plants on public and private land will increase the habitat available to Karner blue butterflies. School children have successfully planted over 1,000 blue lupine plants. Informing the public about native plants will increase the availability of habitat in developed landscapes, and reduce the frequency of mowing habitat plants during critical periods.

Karner blue butterflies have been documented ovipositing and feeding on blue lupine planted by schoolchildren. In areas outside Concord where mowing has been controlled, Karner blue butterfly populations have flourished. Studies have shown that Karner blue butterflies use commercial and residential landscape plants to augment 'natural' habitat.

Karner blue butterfly populations and restoration efforts are currently restricted to Concord, New Hampshire. Efforts will be targeted towards decision-makers, professionals, landowners, and school children within the Concord community.

Restoration and recovery of Karner blue butterflies and their habitat is ongoing and the importance of this work needs to be addressed now and in the long term. Children that plant blue lupine today will provide an immediate benefit, and may support recovery efforts as adults.

Education and outreach can be molded to meet different target audiences (landowners vs. school children) or habitat areas (private land vs. public land), and evolve as new techniques are developed. Content of educational materials can be geared towards specific threats to Karner blue butterflies and their habitat.

(C) Conservation Performance Objectives
- Increase the number of blue lupine plants planted by schoolchildren and other volunteers to more than 500 plants per year for the next 5 years
- Within 5 years, increase the proportion of residential or commercial landowners adopting Karner blue butterfly-friendly management and landscaping practices to more than one-half for buildings currently existing within the potential habitat area
- Within 5 years, increase the proportion of new developments maintained in Karner blue butterfly-friendly management and landscaping practices to more then one-half of the new development plans approved by local planning boards within the potential habitat area
- Increase volunteer participation in restoration activities to more than 20 per year for the next 5 years.

(D) Performance Monitoring
Performance may be monitored via: documentation of the number of blue lupine plants planted each year by school children and other volunteers; random surveys of Concord Heights landowners to determine current land management practices; documenting number of approved plans that adopt Karner blue butterfly-friendly landscaping and management practices; and documenting the number of competent and reliable volunteers.

(E) Ecological Response Objective
The desired ecological response is to increase the availability of blue lupine and nectar plants within and between habitat restoration areas. Successful education and outreach will be indicated by Karner blue butterfly utilization of plants propagated by school children and by Karner blue butterfly utilization of new and existing developed landscapes managed under Karner blue butterfly-friendly programs.

(F) Response Monitoring
Karner blue butterfly use of plants propagated by school children will be documented when it is observed during structured population monitoring as described in the management plan (Fuller et al. 2003). As suitable landscaping is cultivated in the landscape surrounding restoration areas, monitoring will be adapted (with landowner permission) to document Karner blue butterfly movements through habitat between restoration areas.

(G) Implementation
Continue and expand the elementary classroom blue lupine planting program. This is a yearly program partnering NHFG, the National Wildlife Federation, the Roger Williams Park Zoo in Providence, Rhode Island, and the Concord school district funded by grants from Disney and Conservation License plates. Teachers participate in a training session on blue lupine propagation and pine barrens ecology, incorporate the material into curricula, and coordinate a hands-on field trip. Since 2000, over 2300 2nd and 4th graders from 8 local Concord grade schools have completed the program, and over 1,000 blue lupine plants have been planted in the wild. Schoolchildren from local Concord schools grow blue lupine in their classrooms in February and then transplant them in restored Karner blue butterfly habitat at the USFWS Karner Blue Butterfly Easement in May.

Provide native seed mixes to local residents, landscapers and business owners to incorporate into their landscaping. A training program for local landscapers and developers on how to incorporate native seed mixes and plantings into their landscape designs will be developed, along with providing native landscaping guidelines and sources for native seeds and plants. NHFG is collaborating with DRED, Roger Williams Park Zoo and local plant nurseries to collect native seed and prepare seed mixes for distribution. Initially these mixes will be used for NHFG conservation projects, and will be available to the public once a substantial seed bank is accrued.

Present to the Concord planning board and Conservation Commission lectures or materials that focus on ways to minimize impact to Karner blue butterflies and their habitat. NHFG will be contacted to review plans for projects that could potentially impact Karner blue butterflies and pine barrens, and offer guidance to minimize those impacts. Developers will be encouraged to landscape with native vegetation in areas adjacent to pine barrens.

Plan college level educational field trips to the captive rearing lab and pine barrens, targeting university wildlife management and biology students for volunteer and internship opportunities. Encourage butterfly and garden clubs to visit the pine barrens, and volunteer with plant propagation or captive rearing. Develop a volunteer recruitment, training, and maintenance program to involve volunteers in captive rearing and habitat management.

(H) Feasibility
The limiting factor in educational implementation is funding and personnel resources. NHFG is limited in staff and funding to carry out restoration and recovery work. More integration with the Public Affairs Division is needed to focus on education and outreach. Resources must be made available for targeted education material development and training. The National Wildlife Federation has assisted with blue lupine planting by school children and will continue to do so.

4.2 Conservation Action Research

Continue to monitor Karner blue butterfly populations, and search for additional areas where this species could flourish, particularly as pine barrens habitats are restored.

Element 5: References

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5.2 Data Sources

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SPECIES PROFILE

Persius Duskywing

Erynnis persius persius

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5T1T3
State Rank: S1
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Persius duskywing is an associate of the Karner blue butterfly (*Lycaeides melissa samuelis*) and inhabits the grassy openings of the pine barrens (Schweitzer 1992, Kirk 1996). Blue lupine (*Lupinus perennis*) is the larval host plant for Persius duskywing larvae in the Northeast (Schweitzer 1992). Adult Persius duskywing skippers fly from May to mid-June, 1 to 2 weeks before the Karner blue butterfly (Schweitzer 1992, Kirk 1996). Eggs are laid on the underside of blue lupine leaves, and larvae live in rolled up leaf nests where pupa overwinter and pupate in the spring (Kirk 1996). For a detailed habitat description, see the Karner blue butterfly and pine barrens profiles.

1.2 Justification

The Persius duskywing, along with the Karner blue butterfly and frosted elfin (*Callophrys* [*Incisalia*] *irus*), is an indicator of the health of the pine barrens habitat. It is in severe decline in the eastern part of range and disappears before the Karner blue butterfly and frosted elfin as habitats degrade due to habitat loss and fire suppression (Schweitzer 1992). Nearly 90% of historic pine barren communities along the Merrimack River have been lost, leaving 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994). The Persius duskywing is also extremely difficult to identify in the field due to its similarity to other members of the *Erynnis* genus, and therefore, there is some uncertainty about larval food plants and specific habitat requirements (Schweitzer 1992).

1.3 Protection and Regulatory Status

The persius duskywing is protected under the state endangered species act (RSA 212). Blue lupine is listed as threatened in New Hampshire under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution

Extant populations of the Persius duskywing occur in New England, New York, Pennsylvania, New Jersey, Michigan, Wisconsin, and Minnesota (Kirk 1996, NatureServe 2005). Persius duskywing are presumed extirpated in Ontario, along with the Karner blue butterfly and frosted elfin (NatureServe 2005).

In New Hampshire, the Persius duskywing skippers were documented in the pine barrens that ran along the southern portion of the Merrimack River in Merrimack (1879), Milford (1879), Hudson (1975), and Concord (1983, 1988, and 1990) (NHNHB 2005). Despite yearly lepidopteran surveys, the Persius duskywing has not been recorded since 1990 (Mello 1998, Chandler 2001).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information include technical field reports, agency data, scientific journal articles, and element occurrence databases.

1.8 Extent and Quality of Data

There are only 6 documented occurrences of the persius duskywing in New Hampshire (NHNHB 2005). Since this species is very similar to other members of the *Erynnis* genus, proper identification in the field is challenging.

1.9 Distribution Research

Persius duskywing are extremely difficult to identify in the field. Before initiating surveys for this species, voucher specimens are needed and distinguishing characteristics should be noted.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature

Chandler, D.S. 2001. New Hampshire Army National Guard butterfly and moth survey, Concord, New Hampshire. University of New Hampshire, Durham, New Hampshire, USA.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Kirk, K. 1996. The Karner blue community: understanding and protecting associated rare species of the barrens. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Mello, M. 1998. Survey of state-listed and other rare Lepidoptera at proposed Army National Guard, Army Aviation Support Facility lease property, Regional Drive, at Concord Municipal Airport and at other sites within Concord New Hampshire's pine barrens. Lloyd Center for Environmental Studies, South Dartmouth, Massachusetts, USA.

Schweitzer, D. 1992. *Erynnis persius persius* and *Incisalia irus*. The Nature Conservancy, Memorandum of March 3, 1992.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 April 4.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Phyllira Tiger Moth
Grammia phyllira

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Phyllira tiger moth is a grassland species occurring in open, grassy areas including sand prairies, savannas, and pine barrens (NatureServe 2005). In New Hampshire, *Grammia phyllira* utilizes extensive areas of sandy soils associated with pine barrens or old fields (VanLuven 1994). This species is a generalist, with forbs, and presumably grasses, being the primary host plants (NatureServe2005, Wagner personal communication). The flight period of the *G. phyllira* is April to early October (Colvell 1984). For a detailed habitat description, refer to the pine barrens profile.

1.2 Justification
Incomplete

1.3 Protection and Regulatory Status

NHNHB (2005) has identified the *G. phyllira* as a species of very high importance, but the species is currently not protected.

1.4 Population and Habitat Distribution

There are several disjunct ranges for the *G. phyllira*, including the Atlantic coastal region from Maine to Florida as well as the Great Lakes Region from Colorado to Texas (NatureServe 2005, Ferguson et al. 1999). In New Hampshire, *G. phyllira* historically occurred in the towns of Lee, Jaffrey, and Webster. Only one specimen has been collected from the Concord Pine Barrens, in 1993.

1.5 Town Distribution Map
A map is provided.

1.6 Habitat Map
See Karner blue butterfly species profile and the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine *G. phyllira* habitat and distribution.

1.8 Extent and Quality of Data

Data for *G. phyllira* in New Hampshire are limited to the recorded sightings in Concord, Lee, Jaffrey, and Webster. Other areas where pine barrens habitat occurs in New Hampshire have not been surveyed for *G. phyllira*.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of *G. phyllira*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature

Covell, C.V. Jr. 1984. Peterson Field Guides: Eastern Moths. Houghton Mifflin Company, New York, New York, USA.

5.2 Data Sources:

Ferguson, D.C., C.E. Harp, P.A. Opler, R.S. Peigler, M. Pogue, J.A. Powell, and M.J. Smith. 1999. Moths of North America. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/distr/lepid/moths/mothsusa.htm (Version 12DEC2003).

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Pine Barrens Zanclognatha

Zanclognatha martha

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G4
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Zanclognatha martha occupies pine barrens (NatureServe 2005), an early-successional community occurring in coarse-textured, nutrient-poor, droughty soils and dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). The unique habitats vital to *Z. martha* are maintained by frequent disturbance (Wagner et al 2003, Sperduto and Nichols 2004). In New Hampshire, *Z. martha* is associated with open pitch pine forests with a scrub oak-ericaceous understory or closed pitch-scrub oak within the pitch pine-scrub oak woodland system (Mello 1998). The natural history of *Z. martha* has not been fully described. It is thought that the larvae overwinter on the forest floor at the fourth instar stage. Pitch pine was previously considered to be the larval host plant, but more recent research has revealed that *Z. martha* is a detritivore, feeding on dead organic matter, most likely oak leaves (Warren Kiel, personal communication 1994, Massachusetts Natural Heritage 1999). Adults are nocturnal and fly from mid-July to early August (Van Luven 1994).

1.2 Justification

Like other pine barrens lepidoptera, *Z. martha* is an indicator of habitat health. As habitat is lost and fragmented, pine barrens transition to a closed canopy system. As a result, *Z. martha* dies off.

1.3 Protection and Regulatory Status

Z. martha is listed as threatened under the state Endangered Species Act (RSA 212). Refer to the pine barrens profile for habitat protection status.

1.4 Population and Habitat Distribution

Z. martha occurs in Maryland, Virginia, New York, Pennsylvania, New Jersey, Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont (NatureServe 2005). It is very common in parts of New Jersey, but is localized in the remainder of its range (Massachusetts Natural Heritage 1999), NatureServe 2005). In New Hampshire, *Z. martha* has been recorded at 3 sites, including the West Branch of the Ossipee Pine Barrens (1995), the Concord Pine Barrens surrounding the Concord Municipal Airport (1992, 2001), and in the city of Manchester along an old railroad bed flanking the Piscataquog River (2001). Populations are most abundant in mature pitch pine-dominated woodlands (Chandler 2002). Despite encroaching development, *Z. martha* appears capable of maintaining populations within these forests (Chandler 2002).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

1.7 Sources of Information

Habitat and distribution information was obtained from the NatureServe website, state agency literature, field guides, and habitat recovery and conservation plans.

1.8 Extent and Quality of Data

Very little is known about the distribution and natural history of *Z. martha* because of its rarity. Occurrence data were obtained from lepidopteran moth surveys conducted by NHFG, TNC, and university biologists.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of *Z. martha*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4: See the Karner blue butterfly profile and the pine barrens profile.

Element 5: References

5.1 Literature

Chandler, D.S. 2002. New Hampshire Army National Guard butterfly and moth survey, 2001 final report. University of New Hampshire. Durham, New Hampshire, USA.

Farquhar, D.W. 1933-35. List of the Lepidoptera of New England. Unpublished thesis, Harvard University. Collected in Webster, New Hampshire.

Mello, M.J. 1998. Survey of state-listed and other rare Lepidoptera at proposed New Hampshire Army National Guard, Army Aviation Support Facility lease property, Regional Drive at Concord Municipal Airport and at other sites within Concord New Hampshire's Pine Barrens. Report submitted to the New Hampshire Army National Guard, by the Lloyd Center for Environmental Studies. South Dartmouth, MA.

Schweitzer, D.F. 1983. Rare Lepidoptera of the concord, N.H. Pine Barrens with Suggestions for a Potential Preserve. Prepared for the Nature Conservancy, Boston, Massachusetts, USA.

5.2 Data Sources

Kiel, W. 1985. March 20 1994 letter to Julie Malech NHFG from Warren J. Kiel

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Rare plants, rare animals, and exemplary natural communities in New Hampshire towns. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Pine Pinion Moth

Lithophane lepida lepida

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G4T3T4
State Rank: S1S2
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

In New Hampshire, the pine pinion occupies pine barrens (NatureServe 2005), early-successional communities dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). Larval host plants of the pine pinion include red pine (*Pinus resinosa*) and other hard pines (NatureServe 2005, Wagner personal communication). The flight period is from October to late March or early May. Individuals eclose in the fall, overwinter as adults, and emerge again in the spring. For a detailed habitat description, refer to the pine barrens profile.

1.2 Justification

The pine pinion, along with other pine barrens specialists, serves as an indicator of ecological condition. As the habitat goes unmanaged and reverts to a closed canopy system, pine pinion populations become increasingly vulnerable to extirpation.

1.3 Protection and Regulatory Status

The pine pinion is listed as threatened under the New Hampshire State Endangered Species Act.

1.4 Population and Habitat Distribution

Regionally, the pine pinion is spottily distributed from Nova Scotia to Saskatchewan and north to the Pas, Manitoba in Canada. In the United States, it is found in Maine, New York, New Hampshire, and Michigan (NatureServe 2005). In New Hampshire, the species is limited to the xeric pine habitat in the south-central and southern part of the state (Letter from Warren J. Kiel to Julie Malech, 20 March 1994) where it has been documented in the town of Webster and, more recently, in West Branch Pine Barrens in Madison (Farquhar 1933-1935).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile as well as the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine pine pinion habitat and distribution.

1.8 Extent and Quality of Data

Lepidopteran surveys have been conducted at the Concord Pine Barrens and the West Branch Pine Barrens Reserve. Other areas where pine barrens habitat occurs in New Hampshire have not been surveyed for pine pinions.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of the pine pinion. Current populations should be monitored for

trends, and new sites containing key habitat elements should be surveyed.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature

Farquhar, D.W. 1933-35. List of the Lepidoptera of New England. Unpublished thesis, Harvard University. Collected in Webster, New Hampshire.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Schweitzer, D.F. 1983. Rare Lepidoptera of the Concord, N.H. Pine Barrens with suggestions for a potential preserve. Prepared for the Nature Conservancy, Boston, MA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Rare plants, rare animals, and exemplary natural communities in New Hampshire towns. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Puritan Tiger Beetle

Cicindela puritana

Federal Listing: Threatened
State Listing: Not listed
Global Rank: G1
State Rank: SH
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Puritan tiger beetles inhabit wide or narrow sandy beaches adjacent to clay banks or bluffs along the bends of big rivers. Puritan tiger beetles feed on small invertebrates such as amphipods, ants, and flies (Nothngale 1992, United States Fish and Wildlife Service (USFWS) 1993, Leonard and Bell 1999). There are two distinct populations of puritan tiger beetles, one along the Connecticut River in Massachusetts and Connecticut and the other along Chesapeake Bay in Maryland. Larval habitat requirements differ between these two populations (Nothngale 1992, USFWS 1993, Omland 2002). Along the Connecticut River, larvae burrow between sparse herbaceous vegetation (20-30% cover) in fine to medium sand particles (0.125-0.5 mm) at the upper margins of sandy beaches and occasionally near the water's edge (Nothngale 1992, USFWS 1993, Omland 2002). Along Chesapeake Bay in Maryland, larvae burrow in long, high, sandy, and non-vegetated bluff faces (USFWS 1993, Omland 2002).

2.2 Justification

Puritan tiger beetles are the rarest of the New England tiger beetles (Dunn 1986). Succession has degraded suitable habitat, and damming along the Connecticut River has permanently altered the dynamic geological processes that created and maintained habitat. The number of known puritan tiger beetle populations has decreased from 11 to 2 (USFWS 1993).

Minor disturbances to riverine beaches may render the habitat unsuitable for puritan tiger beetle larvae. Because of the 2-year larval period and restricted habitat type, larvae are particularly susceptible to long-term flooding, vegetation encroachment, and other natural or man-made changes to beaches and bluffs (USFWS 1990, Nothnagle 1992, USFWS 1993). Other threats include recreational disturbance, population growth, development, and shore erosion control projects (USFWS 1990, USFWS 1993).

2.3 Protection and Regulatory Status

The puritan tiger beetle is federally Threatened and is protected under the Endangered Species Act.

2.4 Population and Habitat Distribution

Puritan tiger beetles have been historically collected from 11 sites along the Connecticut River from Claremont, New Hampshire to Cromwell, Connecticut (Dunn 1981, USFWS 1993). The upper Connecticut River populations became extirpated in the early 1900s due to dam construction and riverbank stabilization (USFWS 1993). Only 2 Connecticut River populations remain, one near Hadley, Massachusetts and one in Cromwell, Connecticut (USFWS 1990, Nothnagle 1992, USFWS 1993, Omland 2002). Another population of puritan tiger beetles, distinct from the Connecticut River populations, occurs along Chesapeake Bay in Maryland (USFWS 1990, Nothnagle 1992, USFWS 1993, Omland 2002). In New Hampshire, puritan tiger beetles have been historically collected along the Connecticut River in Claremont and Charlestown, and have not been ob-

served in the state since the mid 1930s (Dunn 1978, Dunn 1981).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Sources of information include the species recovery plan, tiger beetle identification guides, peer-reviewed literature, field surveys, and technical reports.

1.8 Extent and Quality of Data

The life history and habitat requirements of puritan tiger beetles are well documented, although most sources are over 10 years old. Current locations of puritan tiger beetles are well known, but historic New England locations are poorly documented. Dispersal patterns are not well known and need further research.

1.9 Distribution Research

Identify and resurvey current and historical locations of puritan tiger beetles.

Element 5: References

5.1 Literature

Dunn, G. A. 1978. Tiger beetles of New Hampshire (Coleoptera: Cicindelidae). Thesis, University of New Hampshire, Durham, New Hampshire, USA.

Dunn, G. A. 1981. The tiger beetles of New Hampshire. Cicindela. 13: 1-28.

Dunn, G. A. 1986. Tiger beetles of New England (Coleoptera: Cicindelidae). Entomological Society Quarterly. 3: 27-41.

Leonard, J. G. and R. T. Bell. 1999. Northeastern tiger beetles: a field guide to tiger beetles of New England and Eastern Canada. CRC Press, Boca Raton, Florida, USA.

Nothngale, P. J. 1992. Puritan tiger beetle monitoring in 1992, and inventory of other species of tiger beetles in the Montague sandplain. A report submitted to the Massachusetts Natural Heritage Program, Westborough, Massachusetts, USA.

Omland, K. S. 2002. Larval habitat and reintroduction site selection for Cicindela puritana in Connecticut. Northeastern Naturalist. 9: 433-450.

United States Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; determination of threatened status for the Puritan tiger beetle and the northeastern beach tiger beetle. Federal Register 55: 32088-32094.

United States Fish and Wildlife Service 1993. Puritan tiger beetle (Cicindela puritana G. Horn) recovery plan. United States Fish and Wildlife Service, Hadley, Massachusetts, USA.

SPECIES PROFILE

Ringed Boghaunter

Williamsonia lintneri

Federal Listing: Not listed
State Listing: Endangered
Affected Species: NA
Global Rank: G3
State Rank: S1
Author: Kim A. Tuttle, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Ringed boghaunters are restricted to sphagnum peatlands and the surrounding upland or mesic forests (Cairns 1998). Ringed boghaunters breed in acidic fens, which are weakly minerotrophic peatlands that receive some nutrients from groundwater springs, seeps, and streams (Lundgren 1999). In New England, breeding and larval habitats include dwarf shrub fens, graminoid-dominated fens, and sphagnum-filled pools or basins. Shrubs, robust sedges and rushes with persistent stems provide places for larvae to emerge in the spring. Aquatic species of Sphagnum are likely an important component of breeding areas and critical for overwintering (Lundgren 1999). Adults may require relatively intact upland forests to rest, develop, and feed before mating (Biber 2002).

1.2 Justification

The majority of ringed boghaunter populations in the United States are located in eastern Massachusetts, Rhode Island, and Wisconsin (NatureServe 2004). New Hampshire and Maine represent the northernmost extent of the known breeding range in the Northeast. Populations that remain in the eastern United States from southern Maine to New Jersey are vulnerable to development. In New Hampshire, ringed boghaunter populations are limited to the southeastern portion of the state, where development pressure is greatest.

There may be more than 50 occurrences of ringed boghaunters in the United States and ongoing surveys will likely reveal new sites, but populations appear to be small with usually fewer than 50 adults (NatureServe 2004). Ringed boghaunters are at risk because of their unique acidic fen habitats that are not well understood. Another Williamsonia dragonfly, the ebony boghaunter (Williamsonia fletcheri), is found in similar sphagnum bog and fen habitats. Like the ringed boghaunter, it is not found in all sphagnum peatlands within its range and its particular habitat requirements remain unknown. The ebony boghaunter appears to be more common than the ringed boghaunter with 8 new sites found in New Hampshire in 2003 and 2004 (P. Hunt, ASNH, personal communication), but is listed as endangered in Maine and Massachusetts where it reaches the southern extent of its range.

1.3 Protection and Regulatory Status

The ringed boghaunter is listed as state endangered in the New Hampshire Endangered Species Conservation Act (RSA 212-A). Fill and Dredge in Wetlands; NHDES (NHDES) (RSA 483-A). See Peatlands profile for other state and federal protection pertaining to ringed boghaunters.

1.4 Population and Habitat Distribution

The ringed boghaunter has a patchy distribution throughout the Northeast. It has recently been documented in Wisconsin and Michigan (NatureServe 2004). In New England, the ringed boghaunter is known from sites in Maine, Massachusetts, Connecticut, New Hampshire, and Rhode Island. Rhode Island accounts for the majority of sites in New Eng-

land with at least 20 occurrences (NatureServe 2004). Only 2 or 3 sites occur in Connecticut (NatureServe 2004). A single breeding site in Maine was found in 1995 at a complex of 5 adjacent fens in southern York County after unsuccessful surveys at approximately 250 potential sites between 1988 and 1995 (Maine Inland Fisheries and Wildlife 2004).

Documented ringed boghaunter breeding locations in New Hampshire are restricted to 4 towns in the southeastern region of the state (Amherst, Litchfield, Kingston, and Durham). It is not known whether historic populations existed beyond this area. In 1990, an adult was collected in Barrington and placed in the Entomology Collection at the University of New Hampshire (UNH) at Durham, but no other details about the site have been located. Another adult was seen at Spruce Hole in Durham in the spring of 1990 by UNH entomology professor Donald Chandler. Spruce Hole is described as a classic kettlehole bog, which is not typical habitat for this species. Ginger Carpenter, the odonatologist at The Nature Conservancy (TNC) Rhode Island Field Office suggested that Spruce Hole might not have supported a breeding population (McCarthy 1995). An adult was seen in Dover south of the easternmost extension of the Bellamy Reservoir by Audubon Society of New Hampshire biologists Pam Hunt and Laura Deming on 4 June 2004. Also in 2004, a resting adult ringed boghaunter was observed at a small cattail marsh near the Massabesic Audubon Center in Auburn. Although these adult dragonflies were not necessarily seen at emergence sites, these observations suggest the presence of additional populations in other parts of the state (P. Hunt, Audubon Society of New Hampshire, personal communication).

3.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Known ringed boghaunter breeding sites were mapped. Peatland habitats were mapped for the CWCS (See Peatlands profile).

1.7 Sources of Information

NatureServe (2004) was used as a source for species status and ranking information. A survey by the NHFG Nongame and Endangered Species Program conducted in 2004 and earlier New Hampshire Natural Heritage Bureau (NHNHB) surveys were used to determine the range of the ringed boghaunter in New Hampshire. The UNH Entomology Collection at Durham was the source of the Barrington record. Further information was taken from published literature, technical field reports, and personal communications. Pam Hunt (Audubon Society of New Hampshire) and M. Marchand (NHFG) provided comments on drafts of this document.

1.8 Extent and Quality of Data

The unique habitat requirements of the ringed boghaunter appear to limit its distribution. While there are only a few sites to monitor for this species, peatlands can be physically difficult to survey for larvae and teneral adults, especially if affected by high water levels in the spring. The early spring emergence of flying adults, well before the bulk of most dragonfly species, has probably caused this species to be overlooked. Growing interest in dragonflies by qualified amateur observers may reveal new breeding locations.

1.9 Distribution Research

Identifying suitable sphagnum peatland habitats and surveying them for exuviae and teneral adults in the spring will help identify new breeding locations for ringed boghaunters. In particular, searches are needed in suitable habitats near the South Berwick site in York County, Maine. A documented occurrence here would extend the distribution of the species in the state. Atlantic White Cedar (Chamaecyparis thyoides) swamps may provide ringed boghaunter habitat (Briggs 1994). It would be relatively easy to survey the limited number of known swamps in southern New Hampshire.

There is a need to create and maintain an Odonate database that is coordinated between NHFG, NHNHB, the New Hampshire Odonate Club, New Hampshire Audubon (P. Hunt), and universities (e.g., University of New Hampshire, Don Chandler). The collection and analysis of these data would allow a more systematic and scientific assessment of the condition of Odonates in New Hampshire. Directing observers to priority sites would enhance the probability of finding new occurrences of at-risk species.

Element 2: Species/Habitat Condition

2.1 Scale

The known breeding populations of ringed boghaunters in New Hampshire are few and restricted to sphagnum peatlands and adjacent woodlands. Individual sites and complexes of sites are appropriate conservation planning units.

2.2 Relative Health of Populations

The Durham Point Sedge Meadow site is the best-documented location of breeding ringed boghaunters in New Hampshire. While small, this population appears to be stable. A 1994 survey of the site by TNC found the minimum estimated population to be 41 individuals (McCarthy 1996). A NHFG survey in 2004 counted at least 41 individuals (exuviae and teneral adults). In most years, the numbers of individuals have been much less, but this may be the result of survey effort and timing that misses the period of peak emergence. The breeding site and surrounding woodland is owned and maintained by TNC. The sedge meadow lies adjacent to Durham Point Road and several adults were observed resting on the road pavement in spring 2004. Continuing residential development and the subsequent rise in traffic volume may increase the likelihood of road mortality to flying and resting adult dragonflies at this site.

Ponemah Fen in Amherst has not been consistently monitored to assess population trends. It had been considered the best site in New Hampshire for ringed boghaunters by TNC because of its large population size, amount of habitat, and relatively undisturbed wetland and surrounding upland (McCarthy 1996). A 1994 survey by TNC determined the minimum population size to be 61 individuals. The 1994 search was the most extensive known at Ponemah Fen, lasting approximately 2 hours by 3 observers (McCarthy 1995). Although much larger in size than any other occupied site, the surrounding upland is being developed rapidly. An adult ringed boghaunter was observed resting on pavement in a nearby driveway in a NHFG survey in 2004.

Three-Way Basin in Litchfield is a complex of basins in a residential neighborhood. The largest number of ringed boghaunters in the complex was documented at the Brenton Street Basin by NHFG in 2004. Despite high water conditions, two people collected 20 ringed boghaunter exuviae in a 45-minute search. The vegetation within and at the edge of this fen remains undisturbed and the large, unfragmented woodlands of Litchfield State Forest to the south may provide refuge and foraging areas for flying adults. The Brenton Sreet Basin may function as a source population for the other smaller basins in the complex that are surrounded by residential development.

Garden Street Fen in Litchfield, located north of Three-Way Basin, is less than 0.4 ha (1 ac). In a survey by TNC in 1994, 3 people found 10 exuviae and 1 teneral adult in a 50-minute search (McCarthy 1995). Until recently, access to the fen for surveys had been somewhat restricted, so the relative health of this population remains unknown.

At the Pow Wow River / Webster Wildlife Area in Kingston, a teneral male was observed in 2000. The site was revisited by NHFG in 2004 when 1 adult was observed resting at the edge of an inactive gravel pit near the entrance to the Webster Wildlife Area. Further efforts are required to adequately survey these extensive aquatic and wooded habitats.

2.3 Population Management Status

Past NHNHB surveys, beginning in the early 1990s, focused on peatlands that contain both Sphagnum and open water. A major peatlands inventory, begun by NHNHB in 1997, identified more potential ringed boghaunter sites. Suitable wetlands north of known locations were identified and partially surveyed in 1998, especially around the New Hampshire border near an adult ringed boghaunter record in Fryeburg, Maine, (Cairns 1998). The NHFG Nongame and Endangered Species Program and TNC have conducted other surveys.

2.4 Relative Quality of Habitat Patches

In 1994, TNC acquired the Durham Point Sedge Meadow and most of its watershed to protect and manage the sedge meadow specifically for the conservation of ringed boghaunters (McCarthy 1996). Contaminated runoff entering the wetland from the adjacent Durham Point Road may threaten the health of this small habitat.

Larger sphagnum peatlands surrounded by intact wetland or upland forests appear to have the most

potential for the long-term persistence of ringed boghaunters. Ponemah Fen and Three-Way Basin (especially Brenton St. Basin) may be of sufficient size and quality to offset the negative effects of adjacent residential development if further upland habitat losses are slowed. The proximity of Three-Way Basin to the large area of woodlands in Litchfield State Forest enhances the long-term viability of this population. The long-term biological cost of adult road mortality and increased predation by domestic animals and subsidized predators is not known. Land fragmentation from residential development around the Garden Street Fen may affect the future viability of this site.

The Pow Wow River / Webster Wildlife Area may be capable of maintaining a viable ringed boghaunter population because of its large size and protected status.

2.5 Habitat Patch Protection Status

TNC owns and protects the Durham Point Sedge Meadow property. Ponemah Fen is privately owned and parcels of the remaining woodlands are distributed among various private owners. The Three-Way Basin Complex is held in several private ownerships, but the Division of Forests and Lands of the State of New Hampshire own the nearby woodlands of Litchfield State Forest. The Litchfield Conservation Commission recently protected the Garden Street Fen. The Pow Wow River / Webster Wildlife Area is owned by the NPNHF.

2.6 Habitat Management Status

Habitat management for the ringed boghaunter is limited to the Durham Point Sedge Meadow and consists of cattail removal to maintain some open water in this small peatland. It is unknown whether this activity has benefited the species.

2.7 Sources of Information

Ringed boghaunter inventory and monitoring reports of New Hampshire sites contain survey data and conservation concerns. Pam Hunt of ASNH and Sara Cairns of NHNHB provided information regarding the protection status of known breeding sites, as well as habitat quality indicators.

2.8 Extent and Quality of Data

The quality of ringed boghaunter reports is very good. Expert observers conducted all surveys and the identification of ringed boghaunter exuviae and adults is relatively easy. The early seasonal hatch and flight period in May eliminates confusion with the majority of dragonfly species whose flight periods begin weeks or months later.

The condition of ringed boghaunter populations in New Hampshire is not well understood. Inconsistency in surveying efforts between years and sites make it difficult to compare between and within populations. Site conditions, especially water levels, greatly influence monitoring results. The flight period for this species is short and early, and exuviae are delicate and easily dislodged from the stems of emergent vegetation by wind or high water. Therefore, the absence of individuals during a single survey does not prove the habitat is unoccupied.

2.9 Condition Assessment Research

The status of the species and its habitat should be regularly monitored because the number and distribution of breeding locations are limited. Additional surveys following up on sightings of flying adults are needed to determine the locations of source populations, particularly at Auburn and Dover sites. Continued surveys for likely wetland habitats are essential to determine and update the status of this species in New Hampshire.

Research is needed to determine the water quality parameters of occupied wetland habitats and to understand the extent of woodland use, including adult dispersal ranges.

A standardized methodology is needed to compare ringed boghaunter populations between years and sites. A consistent survey methodology could reduce the survey effort required to monitor the species (e.g., semi-annual schedule).

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Hydrology

(A) Exposure Pathway
The dredging and filling of peatlands and related hy-

drologic alterations is considered the greatest threat to ringed boghaunter populations, specifically to breeding and larval habitat. In New Hampshire, most of the known locations are protected from dredging and filling, but the long-term effects of altered hydrology by adjacent residential development are uncertain. High water levels and springtime floods in peatland habitats can drown or dislodge teneral adults. Conversely, culvert installation may lower the water or drain small sites adjacent to roads. Low water may expose ringed boghaunter larvae and teneral adults to increased avian and mammalian predation or make the sites unsuitable for aquatic Sphagnum. It is not known whether any small sites have been lost to dredging or filling in the past.

(B) Evidence
While ringed boghaunters do not require permanent standing water to survive, likely because of similar adaptations documented in other Odonates, the length and timing of the hydroperiod at breeding sites may be important for long-term persistence (Biber 2002). The 2-month period between the time ringed boghaunters oviposit in early May and the time of seasonal dry-down may be critical to larval development. Larvae that are not well developed may succumb to desiccation at sites that dry too quickly (Biber 2002).

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Adult ringed boghaunters use upland woodlands surrounding breeding sites.

(B) Evidence
Agricultural, residential, or commercial development may eliminate or disrupt the upland areas that may be required by adult ringed boghaunters to rest, develop, and feed (Biber 2002). The dispersal distances and extent of upland habitat use are not well known.

3.1.3 Transportation Infrastructure

(A) Exposure Pathway
Ringed boghaunter populations appear isolated from each other, partially because of their habitat distribution. Local populations may become more isolated because of development and roads. Little is known regarding dispersal distances for this species. Adult ringed boghaunters are low flyers that can be found resting on sunny surfaces on the ground or asphalt, which exposes them to vehicle mortality. Ringed boghaunters may not be able to recolonize vulnerable smaller sites near roads or other development if catastrophic events destroy a local population.

(B) Evidence
The proximity of the Garden Street Fen to the complex of sites at Three-Way Basin in Litchfield may ensure viable populations if one or more locations need to be recolonized in the future. However, if the Durham Point Sedge Meadow population were lost, the closest known New Hampshire breeding site is in Kingston or possibly Dover. Surveys for ringed boghaunters in Maine may locate additional York County breeding sites closer to the Durham location.

3.1.4 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
The loss of open water through succession or the proliferation of invasive plants such as cattail may crowd out the aquatic Sphagnum and emergent vegetation needed by ringed boghaunters. Fertilizers and leachfield runoff in residential areas may hasten succession.

(B) Evidence
Ringed boghaunters are one of the first odonates to emerge in New Hampshire in the spring, often in the first week of May. Sites that lack old stems and new spring shoots of emergent vegetation, such as Carex and Dulichium, are not likely to be suitable breeding sites (Lundgren 1999). Aquatic species of Sphagnum seem to be an important component of breeding areas (Lundgren 1999). Cattails have been removed at Durham Sedge Meadow to maintain open water.

3.2 Sources of Information

Mike Marchand (NHFG) and Pam Hunt (Audubon Society of New Hampshire) reviewed threats. Scientific literature was used for evidence in the threat assessment.

3.3 Extent and Quality of Data

Since the known breeding sites for ringed boghaunter in New Hampshire are few and accessible, current conditions at each location are noted. The effects of altered hydrology on ringed boghaunter populations is not well understood or documented.

3.4 Threat Assessment Research

Continued monitoring of individual boghaunter breeding sites for habitat and population conditions.

Element 4: Conservation Actions

4.1.1 Protection of ringed boghaunter sites, Habitat Protection

(A) Direct Threats Affected
Development (Habitat Loss and Conversion)

(B) Justification
1) Protecting and managing ringed boghaunter sites will reduce the impact of development on this species.
2) Ringed boghaunter populations depend on the survival of breeding adults. Removing threats to increase adult emergence and successful breeding will help ensure long-term viability.
3) Known ringed boghaunter sites have been mapped and are afforded additional protection under the New Hampshire Endangered Species Conservation Act.
4) Ringed boghaunter sites are few and isolated. All sites are located in southern New Hampshire where development pressures are high. Every ringed boghaunter breeding site needs to be protected quickly with adequate adjacent woodland to prevent population extirpation.
5) Locations of new ringed boghaunter breeding populations should be prioritized for land protection.

(C) Conservation Performance Objective
Protect all known ringed boghaunter breeding sites and adjacent woodlands. The minimum extent of upland use by adults needs to be determined for the purpose of protection. Undiscovered breeding sites are at the greatest risk. These locations, especially those that are extremely small in size, may go undetected during the wetland review process and may be subject to damage from filling or logging before protection. New occurrences of adult ringed boghaunters need to be located in a timely fashion.

(D) Performance Monitoring
Continue ringed boghaunter inventories to monitor established sites and identify new sites for protection. Maintain a database of known ringed boghaunter sites, unprotected lands, and landowner contact information.

(E) Ecological Response Objective
Protect peatland breeding sites and an ample wooded buffer to help maintain viable populations of ringed boghaunters in New Hampshire.

(F) Response Monitoring
Monitor breeding sites for population stability and colonization of nearby suitable peatland breeding habitat.

(G) Implementation
Secure protection for Ponemah Fen and any remaining adjacent woodlands and the Three-Way Basin Complex, especially the larger Benton Street Basin. Work with appropriate conservation partners to secure easements or purchase land outright. Use occupied sites to prioritize landscape level habitat protection.

(H) Feasibility
The NHFG is limited in its ability to protect land through easement or purchase. Protection efforts may rely on the involvement of conservation commissions and planning boards, particularly in Amherst and Litchfield.

4.1.2 Communicate to landowners, abutters, town administrators and departments, local conservation organizations and commissions about ringed boghaunter status and habitat, Education and Outreach.

(A) Direct Threats Affected
Development (Habitat Loss and Conversion), Altered Natural Disturbance (Natural Succession)

(B) Justification
1) Most people, including natural resource professionals, are unaware of the presence of a state-endangered dragonfly in New Hampshire.
2) Sites are primarily adjacent to residential development. Removing threats associated with residential development through education will help increase the probability of long-term survival of local ringed boghaunter populations.
3) Efforts will be directed towards specific locations where ringed boghaunter populations have been documented.
4) Sites are at immediate risk from uninformed actions by private individuals and those authorized by public agencies (i.e., application of lawn chemicals near peatlands and mosquito control larvicides).
5) Brochures or other educational materials can be updated with new information to benefit ringed boghaunters conservation.

(C) Conservation Performance Objective
Increase awareness of the ringed boghaunter and its peatland and upland habitats. Reduce direct and incidental damage to peatlands by chemical application and runoff from landowners and abutters.

(D) Performance Monitoring
Regularly monitor ringed boghaunter sites and communicate with local conservation commissions and residents to discuss problems.

(E) Ecological Response Objective
Outreach and education should increase the probability that local ringed boghaunter populations will persist into the future.

(F) Response Monitoring
Develop baseline water quality indicators for peatlands and regularly sample to detect changes in water chemistry at specific peatland sites. Monitoring is especially needed at unprotected sites that are surrounded by residential development and would benefit from education and outreach efforts (e.g., Three-Way Basin, Ponemah Fen).

(G) Implementation
Work with NHFG Public Affairs Division or other organizations such as TNC to develop a brochure featuring the ringed boghaunter. Distribute brochures to ringed boghaunter site owners, abutters and town officials and departments whose activities may affect sites such as public works. Follow up on activities that are detrimental to ringed boghaunter sites with contact to specific individuals or relevant agencies.

(H) Feasibility
Brochures are a cost-effective way to inform people about ringed boghaunters.

4.2 Conservation Action Research

N/A

Element 5: References

5.1 Literature

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5.2 Data Sources

Maine Inland Fisheries and Wildlife. 2005. Ringed boghaunter in invertebrates listed in Maine. <http://www.state.me.us/ifw/wildlife/etweb/group/rbog.htm>. Accessed 2005 February 26.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer>. Accessed 2004 December 29.

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development. Concord, New Hampshire, USA.

SPECIES PROFILE

Sleepy Duskywing
Erynnis brizo brizo

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T5
State Rank: S2
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The sleepy duskywing is an associate of the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*) and inhabits the shrub-scrub layer of pine barrens (Scott 1986, Opler and Malikul 1992, Glassberg 1993). Sleepy duskywing larvae predominately feed on scrub oak (*Quercus ilicifolia*) leaves and buds, along with other shrubby oaks (Opler and Malikul 1992, Glassberg 1993, Mello 1998). Adult sleepy duskywings fly from April to June (Scott 1986, Opler and Malikul 1992, Glassberg 1993). Eggs are laid singly on scrub oak leaves and larvae live in rolled up leaf nests, eventually overwintering (Scott 1986). For a detailed habitat description, see Karner blue butterfly species profile and pine barrens habitat profile.

1.2 Justification

The sleepy duskywing can be found in the same habitat as the Karner blue butterfly and frosted elfin (*Callophrys* [*Incisalia*] *irus*), which are indicator species of the health of the pine barrens habitat. The sleepy duskywing is in severe decline in the eastern part of range due to habitat loss and fire suppression; nearly 90% of historic pitch pine-scrub oak barren communities along the Merrimack River have been lost, leaving a mere 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994).

1.3 Protection and Regulatory Status

Although the sleepy duskywing is not state or federally listed, it is protected as an associate of blue lupine, which is listed as threatened in New Hampshire and protected under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution

The range of the sleepy duskywing extends across all of the eastern states to Minnesota and Texas, and in the west in parts of California, Arizona, New Mexico, Utah, and Colorado (Scott 1986, Opler and Malikul 1992,Glassberg 1993). In New Hampshire, the sleepy duskywing was documented in the Concord pine barrens in 1998 and 2001 and in the Ossipee pine barrens in 1985 (Chandler 2001, New Hampshire Natural Heritage Bureau 2005).

1.5 Town Distribution Map
A map is provided.

1.6 Habitat Map
N/A

1.7 Sources of Information

Sources of information included technical field reports, field guides, and element occurrence databases.

1.8 Extent and Quality of Data

There are only 2 documented locations for the sleepy duskywing in New Hampshire (Chandler 2001, NHNHB 2005). Since this species is very similar to other members of the *Erynnis* genus, proper identification in the field is challenging.

1.9 Distribution Research

Before initiating surveys for this species, voucher specimens are needed and distinguishing characteristics should be noted.

Elements 2-4: See Karner blue butterfly profile or pine barrens habitat profile.

Element 5: References

5.1 Literature

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Opler, P.A., and V. Malikul. 1992. Peterson field guides: eastern butterflies. Houghton Mifflin. New York, New York, USA.

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5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

White Mountain Arctic

Oeneis melissa semidea

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T2
State Rank: S2
Authors: Celine T. Goulet and Steven G. Fuller, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The White Mountain arctic is a subspecies of the Melissa arctic (*Oeneis melissa*) and is endemic to the alpine zone of the Presidential Range of New Hampshire (McFarland 2003). It inhabits alpine and subalpine communities above 4,900 ft, specifically the dwarf shrub/sedge-rush meadow community (Chandler 2001, McFarland 2003). Dwarf shrub/sedge-rush meadows are composed of 4 communities: alpine heath snowbank, Bigelow's sedge meadow, sedge-rush-heath meadow, and dwarf shrub-bilberry-rush barren. These communities occur at elevations ranging from 1,340 to 1,890 m on moderate slopes oriented to the northwest and are characterized by Bigelow sedge (*Carex bigelowii),* Highland rush (*Juncus trifidus*), and dwarf heath (*Vaccinium* spp.) (McFarland 2003, Sperduto and Nichols 2004). The ground cover is comprised of herbs, forbs, moss, lichen, and sparse, rocky openings interspersed with Bigelow sedge, the host plant for White Mountain arctic (Chandler 2001). Adults primarily feed on Moss campion (*Silene acaulis*), Mountain sandwort (*Arenaria groenlandica*), and *Vaccinium* species (McFarland 2003).

1.2 Justification

White Mountain arctic is limited to a 2,800 ac alpine zone of the White Mountain National Forest (WMNF). The species is highly susceptible to climate changes and population declines because of its fragile habitat, isolation, and host plant specificity (Halloy and Mark 2003, McFarland 2003). The structure, composition, phenology, and distribution of alpine habitat communities are extremely susceptible to climate change (Kimball and Weihrauch 2000, McFarland 2003, Lesica and McCune 2004). Alpine plant and animal species respond interdependently to environmental changes, expanding or contracting their ranges in relation to polarity and elevation (McFarland 2003, Lesica and McCune 2004). Asynchronous range fluctuations could disrupt plant-animal interactions such as pollination, seed dispersal, and food availability. This could lead to biotic feedbacks that are detrimental to overall ecosystem function (Bowman 2000, Walther et al. 2002). The obligate host plant of White Mountain arctic is Bigelow's sedge, a rare high-elevation plant that characterizes Bigelow's sedge meadows (S1) (McFarland 2003, Lesica and McCune 2004). Additional threats may emerge as climate continues to change, especially as climate interacts with other stressors such as habitat fragmentation, acid deposition, and increased solar ultraviolet radiation (McCarty 2001).

1.3 Protection and Regulatory Status

White Mountain arctic is designated as a WMNF sensitive species (Chandler 2001). Natural communities diagnostic of habitat are state-ranked (see above).

1.4 Population and Habitat Distribution

White Mountain arctic, a glacial relict, was once more widely distributed throughout New Hampshire, but has since become isolated as the climate warmed at the end of the last glaciation 13,000 years ago (McFarland 2003). Currently, disjunct popula-

tions of White Mountain arctic are restricted to the 2,800 ac alpine zone of the Presidential Range of the WMNF (Chandler 2001, McFarland 2003). Its presence depends on the abundance of host plants as well as ground temperature, moisture, and winter snow depth (Anthony 1970, McFarland 2003). White Mountain arctic populations tend to be locally abundant around sedge meadows, a community covering approximately 198 ac (7%) of the alpine zone within the Presidential Range (McFarland 2003). The northernmost record is from Mt. Jefferson and the southernmost from Mt. Monroe, with the greatest number of observations occurring at Monticello Lawn on Mt. Jefferson, Gulf Tanks along the Mt. Washington Cog Railway, the Cow Pasture, and the Bigelow Lawn on Mt. Washington (McFarland 2003).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Alpine Habitat Profile; occupies only Presidential unit.

1.7 Sources of Information

Published literature and New Hampshire Natural Heritage Bureau (NHNHB) database.

1.8 Extent and Quality of Data

The New Hampshire distribution of White Mountain arctic is well documented.

1.9 Distribution Research

Three areas of research are needed to better understand and protect this species, including taxonomic study to determine species/subspecies status, identification of population trends, and determination of its population structure.

Element 2: Species/Habitat Condition

2.1 Scale

See Alpine Habitat Profile; occupies only Presidential unit.

2.2 Relative Health of Populations

Relative abundance within the Presidential Unit is unknown, however, the White Mountain arctic population is considered imperiled due to natural rarity (McFarland 2003) and susceptibility to climatic and atmospheric changes.

2.3 Population Management Status

Surveys have been conducted but long-term monitoring has not been implemented. Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the WMNF.

2.4 Relative Quality of Habitat Patches

High quality occurrences of alpine communities used by White Mountain arctic occur in Alpine Garden, Tuckerman Ravine, Oakes Gulf, Great Gulf, Mt. Eisenhower, Mt. Franklin, Monroe Flats, Bigelow Lawn, the upper slopes of Mt. Adams, Monticello Lawn, and on the north and west sides of the cone of Mt. Washington (Sperduto and Nichols 2004). Records of adult White Mountain arctic are most often reported from the following sedge meadows: Monticello Lawn on Mt. Jefferson, area surrounding Gulf Tanks along the Mt. Washington Cog Railway, the Cow Pasture, the Alpine Garden, and the Bigelow Lawn on Mt. Washington (McFarland 2003).

2.5 Habitat Patch Protection Status

Because White Mountain arctic is not protected under the Endangered Species Act or RSA 212, its habitat receives no special protection. See also Alpine Habitat Profile.

2.6 Habitat Management Status

Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the WMNF. See also Alpine Habitat Profile.

2.7 Sources of Information

Information regarding the management and protection of alpine habitat was obtained from the Proposed Land and Resource Management Plan for the WMNF; 2001 memorandum of understanding between the Bureau of Land Management (BLM), National Park Service (NPS), United States Forest Service (USFS), United States Department of Transportation, and National Endowment for the Arts; 1996 National Scenic Trail comprehensive management plans; and documents delineating the Wilderness Act.

2.8 Extent and Quality of Data

Abundance data are inadequate to allow rigorous population estimates.

2.9 Condition Assessment Research

Research priorities include evaluation of taxonomic status, population structure, and patterns of habitat use. A monitoring scheme featuring at least 20 randomly located transects throughout the alpine zone and surveyed utilizing the distance sampling method at least every 5 days throughout the flight period needs to be developed (McFarland 2003).

Element 3: Species and Habitat Threat Assessment

3.1.1 Climate Change

(A) Exposure Pathway
Climate change may reduce or extirpate local populations of Bigelow's sedge and other alpine flora. This could in turn limit the reproductive, foraging, and dispersal success of alpine lepidoptera, ultimately leading to extinction.

(B) Evidence
The interaction between topography and climate determines alpine plant community distribution (Kimball and Weihrauch 2000). Climate change could significantly alter the range and composition of alpine habitat (Kimball and Weihrauch 2000). Species respond by shifting their ranges poleward and upward in elevation, resulting in a rise in treeline (Roland et al. 2002, Walther et al. 2002, McFarland 2003). This often displaces alpine meadow species with lower-elevation species (McFarland 2003, Lesica and McCune 2004). Smaller and more isolated alpine meadows may pose challenges for alpine species to disperse among them and maintain populations (Roland et al. 2002). Movement of the alpine butterfly *Parnissius smintheus* is severely reduced by forests encroaching into meadow habitats (Roland et al. 2002).

3.1.2 Climate Change

(A) Exposure Pathway
Climate change may result in asynchronous timing of phenological responses of Bigelow's sedge and other alpine flora with alpine Lepidoptera, reducing availability of host plants, larval forage, and nectar plants.

(B) Evidence
A significant correlation exists between phenological patterns and environmental cues, primarily snowpack, in alpine communities (Walker et al 1995). The timing of snow release greatly affects initiation of growth and flowering of most alpine species; this is an adaptation to limited moisture and short growing season (Walker et al. 1995). The timing of lepidopteran life history stages and behavioral patterns is heavily influenced by temperature. In New Hampshire, temperatures have increased by 0.7 degrees°F, 2 to 3 times the regional average, (New England Regional Assessment 2001, Harvey 2003). As a response, freeze-free periods in many subalpine/alpine regions are lengthening and duration of snow and ice cover is decreasing (Walther et al. 2002). Several studies have documented long-term phenological changes of both alpine vegetation and lepidoptera induced by climate change, leading to perturbations in inter-specific relationships and availability of host and nectar plants (Walther et al. 2002).

3.1.3 Climate Change

(A) Exposure Pathway
Elevated solar UV-B radiation associated with stratospheric ozone depletion can significantly alter plant chemistry, impacting the level of herbivory, food plant availability, and rate of larval development, and increasing susceptibility to population declines (Caldwell et al 1998, Nigel 2005).

(B) Evidence
Elevated solar UV-B radiation associated with stratospheric ozone depletion can significantly alter the plant chemistry, inducing changes in leaf morphology, nitrogen concentration, and phenology (Caldwell et al 1998, Nigel 2005). UV-B changes in plant-herbivore interactions can be attributed to alterations in plant nitrogen or sugar content resulting from elevated solar UV-B radiation levels (Caldwell et al. 1998, Nigel 2005). UV-B responses are expected to interact adversely with the effects of climate change (Caldwell et al. 1998).

3.2 Sources of Information

Information regarding threats to White Mountain arctic was compiled from management plans, technical field reports, and scientific journals.

3.3 Extent and Quality of Data

Threats affecting White Mountain arctic and its habitat are well-documented in the scientific literature, with extensive research on habitat alteration and range shifts due to climate change as well as increasing atmospheric pollution.

3.4 Threat Assessment Research

Further research should focus on habitat alterations resulting from climate change and acid deposition, including changes in community and species distributions, abundance, and phenology. Changes in plant chemical composition and morphology induced by increased UV-B radiation need investigation.

Element 4: Conservation Actions

- List White Mountain arctic Under FIS 1000, Regulation, and Policy (see Strategies, Agency Regulation and Policy, Revise/Enforce RSA 212 and FIS 1000)
- List White Mountain arctic on Extinction Advisory, Regulation, and Policy (see Strategies, Regional Coordination, Advise IAFWA)
- Advise Trail Managers on Mitigation for Habitat Impacts, Regulation and Policy (see Alpine Habitat Profile, see also Strategies, Recreational Management)
- Develop White Mountain arctic Captive Breeding Methods, Population Management (see Strategies, Population Management, Captive Breeding in Zoos)
- Monitor White Mountain arctic Habitat Plants, Monitoring (see Strategies, Monitoring, Indicators of Climate Change)
- Monitor White Mountain arctic , Monitoring (see Strategies, Monitoring, Indicators of Climate Change)

4.2 Conservation Action Research

Develop methods to perpetuate habitat; delineate potential habitat for translocation.

Element 5: References

5.1 Literature

Anthony, S.G. 1970. Field work on the population structure of *Oeneis melissa semidea* (Satyridae) from the Presidential Range, New Hampshire. Journal of Research on the Lepidoptera 7(3):133-148.

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USDA Forest Service. 2004. Land and Resource Management Plan for the White Mountain National Forest. USDA Forest Service, Eastern Region, USA.

SPECIES PROFILE

White Mountain Fritillary

Boloria titania montinus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T2
State Rank: S2
Authors: Celine T. Goulet and Steven G. Fuller, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The White Mountain fritillary, a subspecies of the Purple fritillary (*Boloria titania*), is endemic to the alpine zone of the Presidential Range of New Hampshire (McFarland 2003). White Mountain fritillary inhabits wet-mesic alpine communities above 1,220 to 1,860 m, specifically wet alpine meadows, alpine streamside communities, and snowbank communities (Chandler 2001, McFarland 2003). Wet-mesic alpine communities are typically sloped, have shallow organic soils, and are associated with late-melting snowbanks forming in lee positions of summits, ridges, outcrops, ravines, drainages, and at the alpine-treeline interface. Characteristic vegetation consists of *Geum peckii, Solidago cutleri, Spiraea septentrionalis, Scirpus cespitous, Salix spp.,* and *Vaccinium* spp. (Sperduto and Nichols 2004). The preferred habitat of White Mountain fritillary includes a ground cover composed of herbs and forbs, host and nectar sources, and proximity to water (Chandler 2001). No obligate larval host plants are known, although possible species include *Salix spp*., *Viola palustris*, *Viola adunca*, and *Vaccinium spp*. (McFarland 2003). Adults prefer *Solidago cutleri* but will also nectar on *Aster* species (McFarland 2003).

1.2 Justification

White Mountain fritillary is limited to the 2,800 ac alpine zone of the White Mountain National Forest (WMNF). The natural communities used most frequently by White Mountain fritillary ranked S1 in New Hampshire. Climate change will likely alter alpine habitat structure, composition, phenology, and distribution, all of which directly impact White Mountain fritillary populations (Kimball and Weihrauch 2000, McFarland 2003, Lesica and McCune 2004). Habitat isolation further increases the species' vulnerability (Halloy and Mark 2003, McFarland 2003). Interdependent responses to climate change could disrupt ecological interactions throughout the alpine community, reducing the ability of sensitive species to endure other environmental stresses, such as acid deposition and increased UV-B radiation (McCarty 2001).

1.3 Protection and Regulatory Status

White Mountain fritillary is designated as a WMNF sensitive species. Natural communities diagnostic of habitat are state-ranked (see above).

1.4 Population and Habitat Distribution

White Mountain fritillary, a glacial relict, was once widely distributed in New Hampshire, but has become isolated with post-glacial warming (McFarland 2003). Currently, disjunct populations of White Mountain fritillary are restricted to the 2,800 ac alpine zone of the Presidential Range of the WMNF (Chandler 2001, McFarland 2003). Habitat suitability depends on the abundance of host plants, particularly Alpine goldenrod, as well as ground temperature, moisture, and winter snow cover (Anthony 1970, McFarland 2003). White Mountain fritillary populations tend to

be locally abundant near herbaceous snow bank communities, a community covering approximately 7 ac (less than 1%) of the alpine zone within the Presidential Range (McFarland 2003). The northernmost occurrence is from Mt. Madison and the southernmost is Mt. Pierce at an elevation range of 1,220 to 1,860 m, with the highest densities at Cragway Spring and Wamsutta Trail (McFarland 2003). The only historical record occurring outside the Presidential Range alpine zone was a specimen collected by D. J. Lennox on 27 August 1966 in Jefferson Notch at 900 m elevation and deposited in the University of New Hampshire collections (McFarland 2003).

1.5 Town Distribution Map

A map is provided

1.6 Habitat Map

See Alpine Habitat profile; occupies only Presidential unit.

1.7 Sources of Information

Published literature and New Hampshire Natural Heritage Bureau (NHNHB) database

1.8 Extent and Quality of Data

The New Hampshire distribution of White Mountain fritillary is well documented.

1.9 Distribution Research

Three areas of research are needed to better understand and protect this species, including taxonomic study to determine species/subspecies status, identification of population trends, and determination of its population structure.

Element 2: Species/Habitat Condition

2.1 Scale

See Alpine Habitat profile; occupies only Presidential Unit.

2.2 Relative Health of Populations

Relative abundance within the Presidential Unit is unknown, however, the White Mountain fritillary population is believed to be imperiled due to natural rarity (McFarland 2003) and susceptibility to climatic and atmospheric changes.

2.3 Population Management Status

Surveys have been conducted but long-term monitoring has not been implemented. Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the WMNF.

2.4 Relative Quality of Habitat Patches

High quality alpine communities used by White Mountain fritillary occur in the Alpine Garden, Tuckerman Ravine, Oakes gulf, Great Gulf (Sperduto and Nichols 2004). Records of adult White Mountain fritillary are most often reported from Cragway Spring and Wamsutta Trail, each with high densities of *Solidago cutleri* (McFarland 2003).

2.5 Habitat Patch Protection Status

Because White Mountain fritillary is not protected under ESA or RSA 212, itshabitat receives no special protection. See Alpine Habitat Profile.

2.6 Habitat Management Status

Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the White Mountain National Forest. See also Alpine Habitat Profile.

2.7 Sources of Information

Information regarding the management and protection of alpine habitat was obtained from the Proposed Land and Resource Management Plan for the WMNF; 2001 memorandum of understanding between the Bureau of Land Management (BLM),

National Park Service (NPS), United States Forest Service (USFS), United States Department of Transportation (USDOT), and National Endowment for the Arts; 1996 National Scenic Trail comprehensive management plans; and documents delineating the Wilderness Act.

2.8 Extent and Quality of Data

Abundance data are inadequate to allow rigorous population estimates.

2.9 Condition Assessment Research

Research priorities include evaluation of taxonomic status, population structure, and patterns of habitat use. A monitoring scheme featuring at least 20 randomly located transects throughout the alpine zone and surveyed utilizing the distance sampling method at least every 5 days throughout the flight period needs to be developed (McFarland 2003).

Element 3: Threat Assessment

3.1.1 Climate Change
See O. m. semidea Profile

3.1.4 Recreation
See Alpine Habitat Profile

3.2 Sources of Information

Information regarding threats to White Mountain fritillary was compiled from management plans, technical field reports, and scientific journals.

3.3 Extent and Quality of Data

Threats affecting White Mountain fritillary and its habitat are well documented throughout the scientific literature, with extensive research concentrated on habitat alteration and range shifts due to climate change as well as increasing atmospheric pollution.

3.4 Threat Assessment Research
See O. m. semidea Profile and Alpine Habitat Profile

Element 4: Conservation Actions

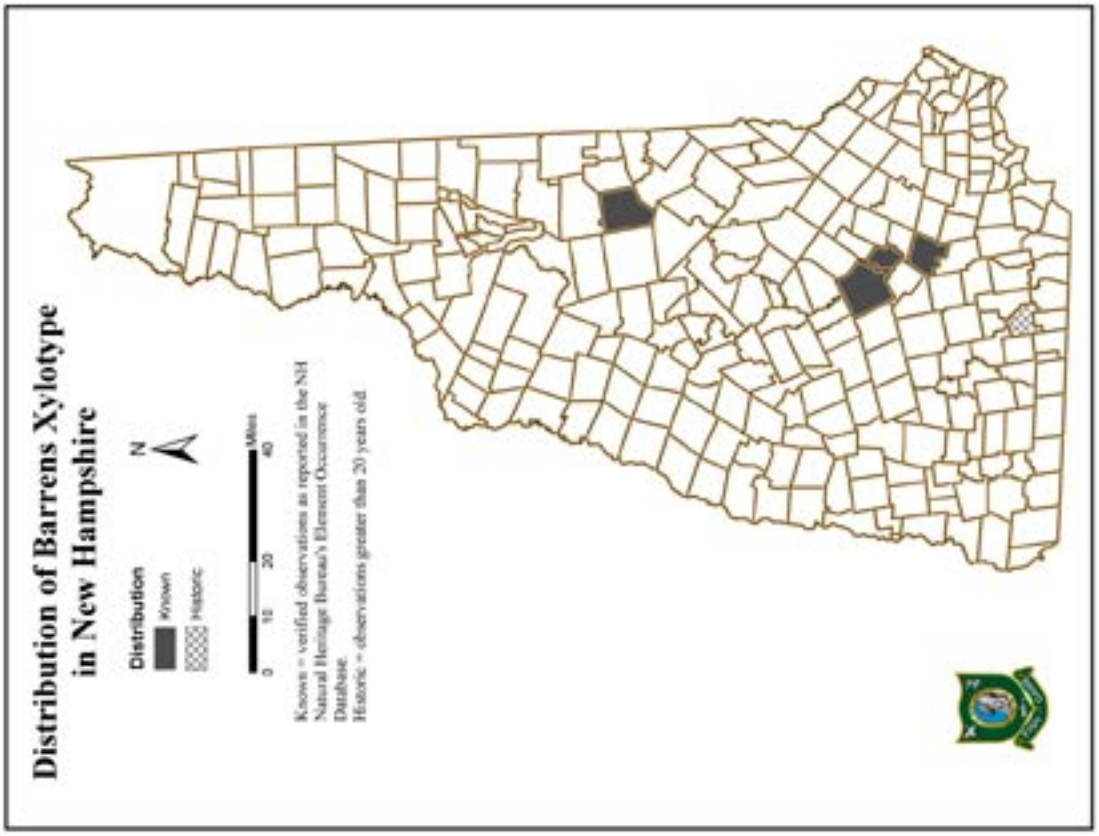
- List White Mountain fritillary Under FIS 1000, Regulation and Policy (see Strategies, Agency Regulation and Policy, Revise/Enforce RSA 212 and FIS 1000)
- List White Mountain fritillary on Extinction Advisory, Regulation and Policy (see Strategies, Regional Coordination, Advise IAFWA)
- Advise Trail Managers on Mitigation for Habitat Impacts, Regulation and Policy (see Alpine Habitat Profile, see also Strategies, Recreational Management)
- Develop White Mountain fritillary Captive Breeding Methods, Population Management (see Strategies, Population Management, Captive Breeding in Zoos)
- Monitor White Mountain fritillary Habitat Plants, Monitoring (see Strategies, Monitoring, Indicators of Climate Change)
- Monitor White Mountain fritillary, Monitoring (see Strategies, Monitoring, Indicators of Climate Change)

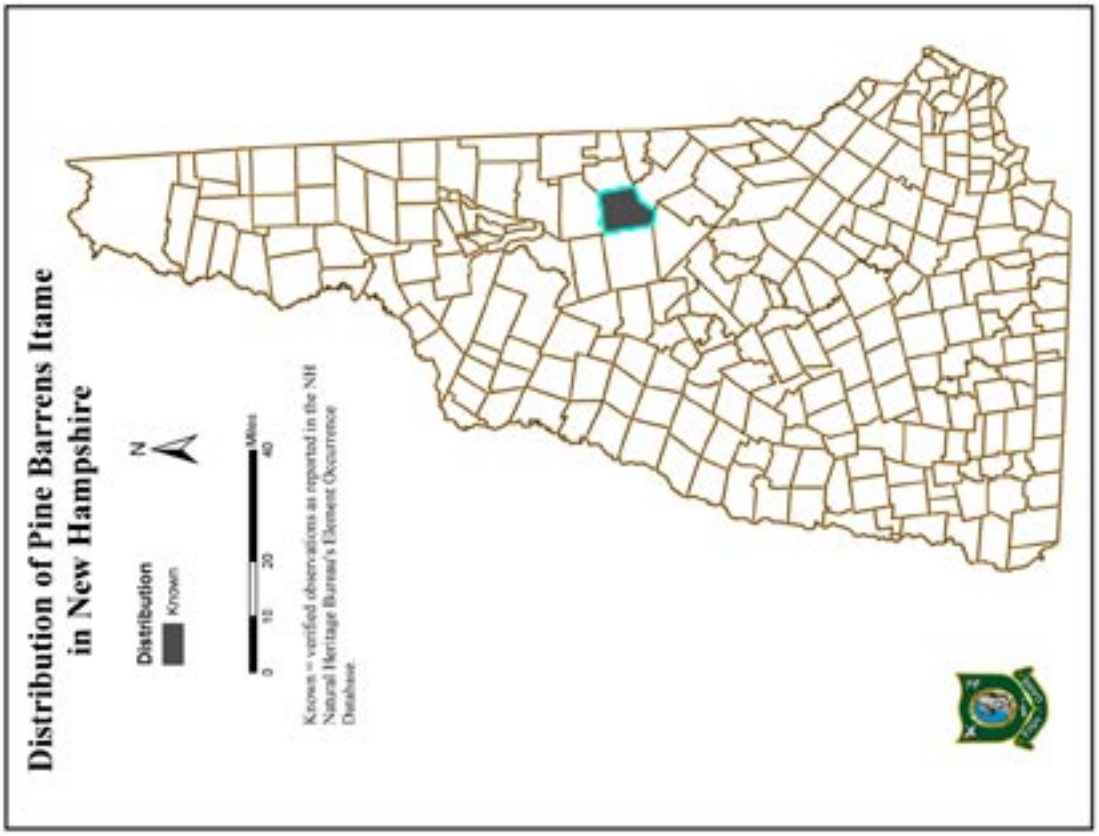
Element 5: References

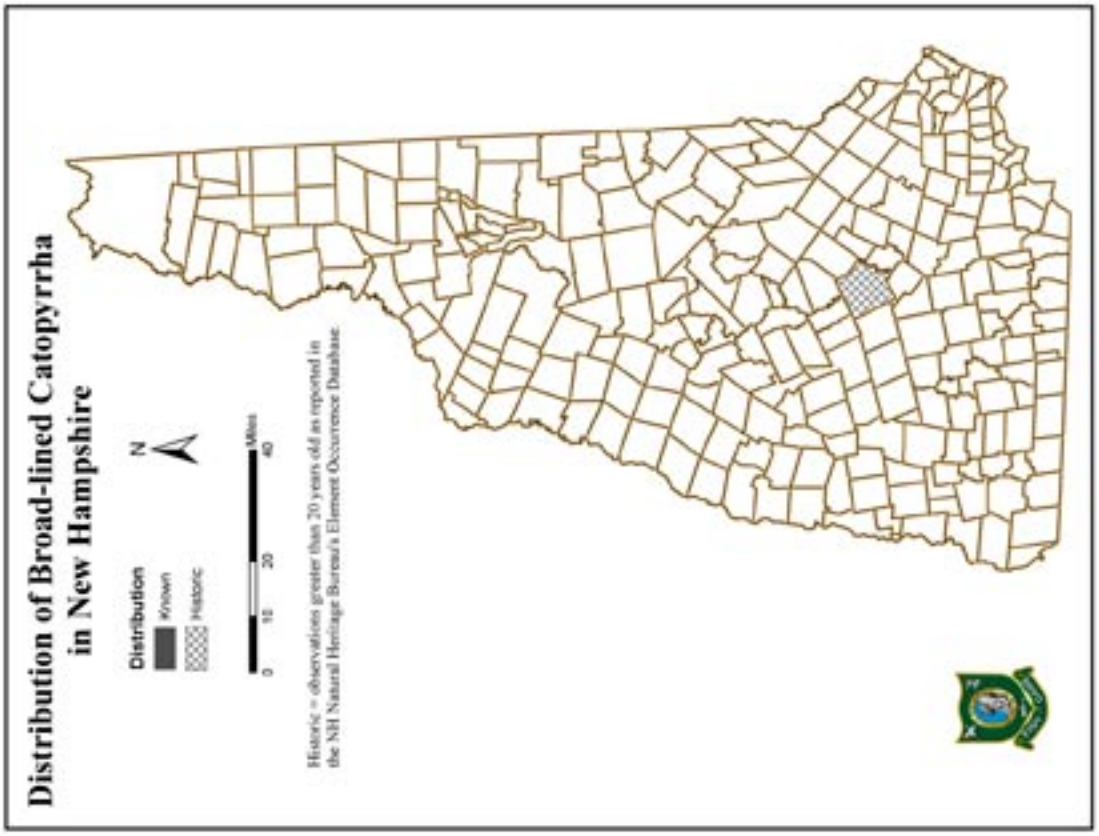
5.1 Literature
See O. m. semidea Profile

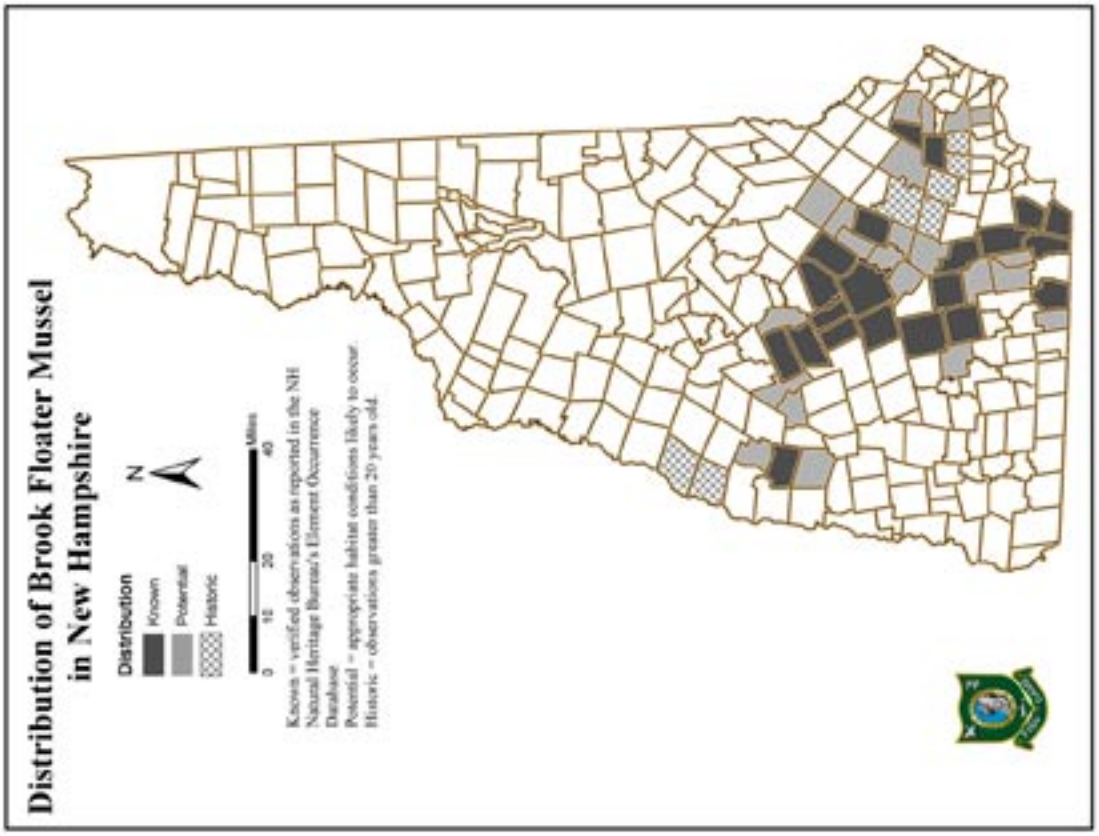
5.2 Data Sources
See O. m. semidea Profile

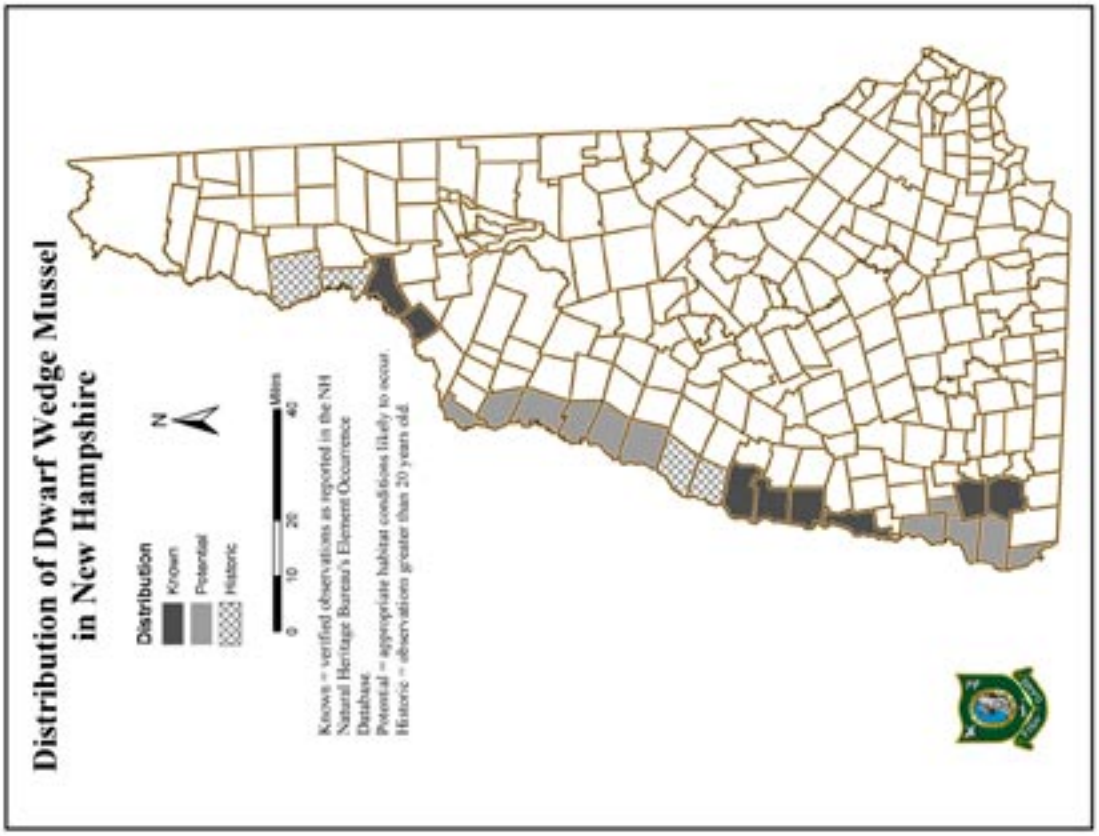
Invertebrate Maps

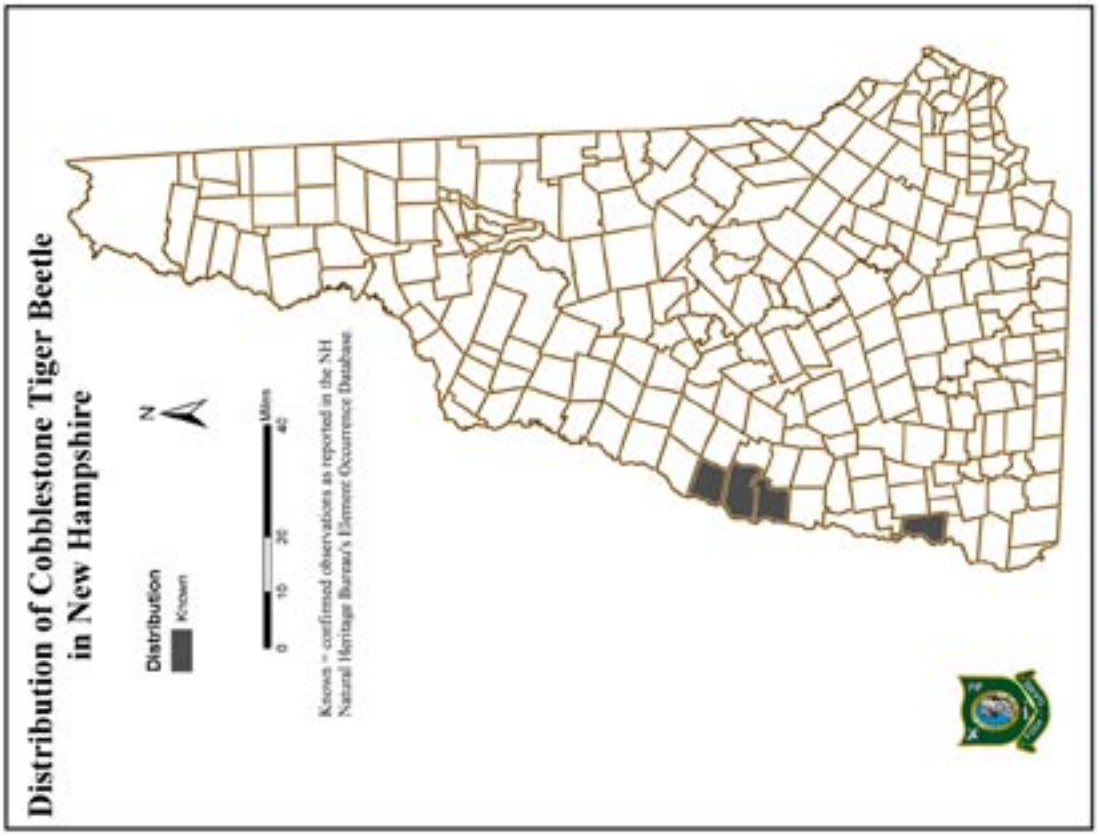

Distribution of Barrens Xylotype in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Historic = observations greater than 20 years old.

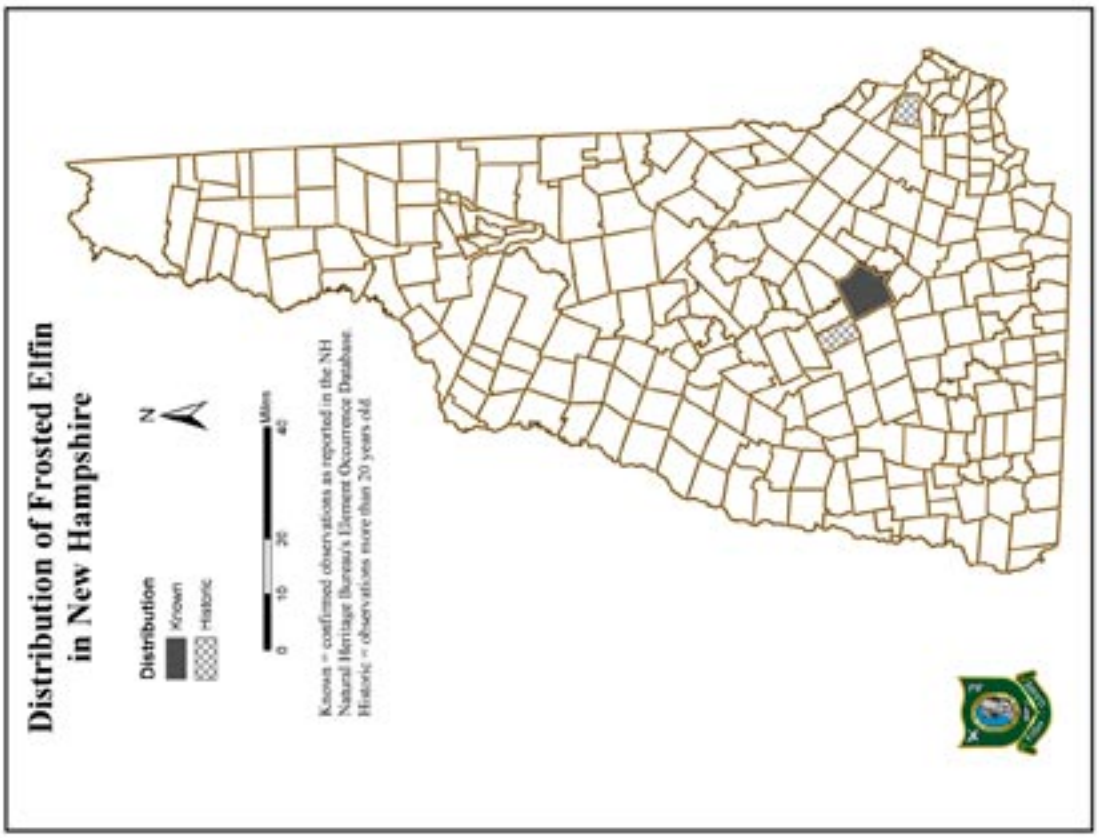

Distribution of Pine Barrens Itame in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of Broad-lined Catopyrrha in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Historic = observations greater than 20 years old as reported in the NH Natural Heritage Bureau's Element Occurrence Database.

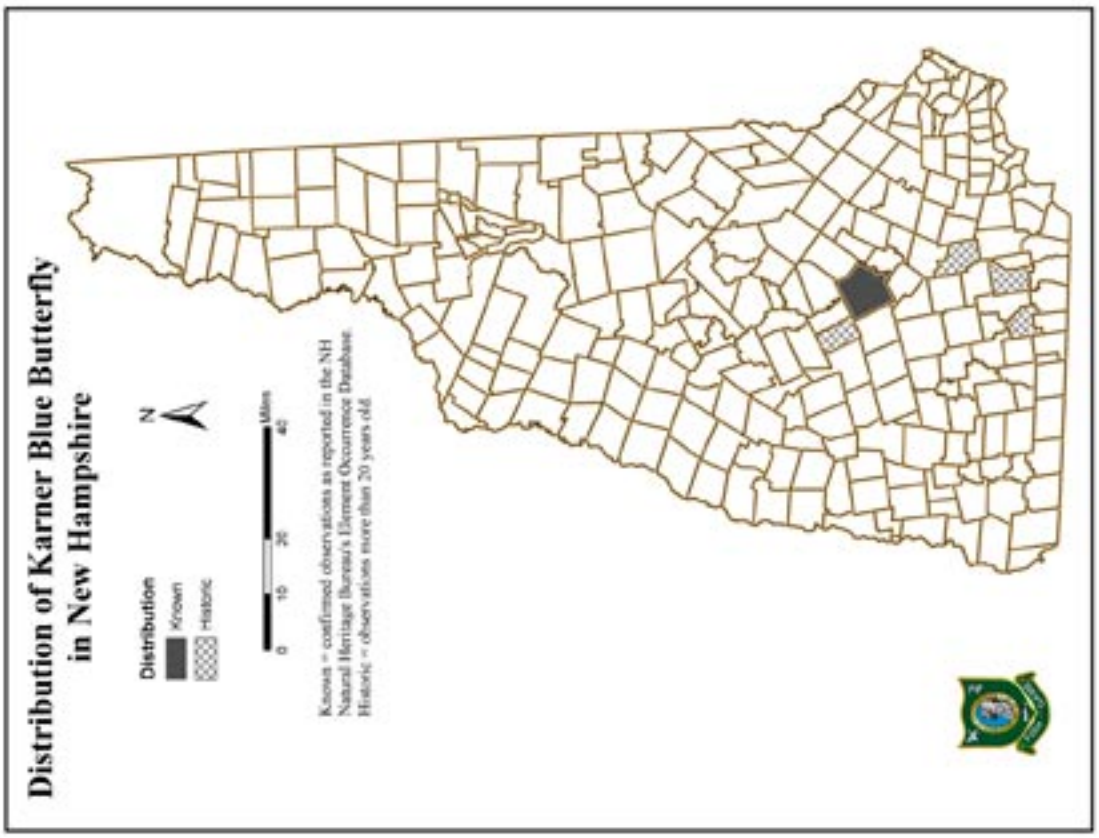

Distribution of Brook Floater Mussel in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database
Potential = appropriate habitat conditions likely to occur
Historic = observations greater than 20 years old.

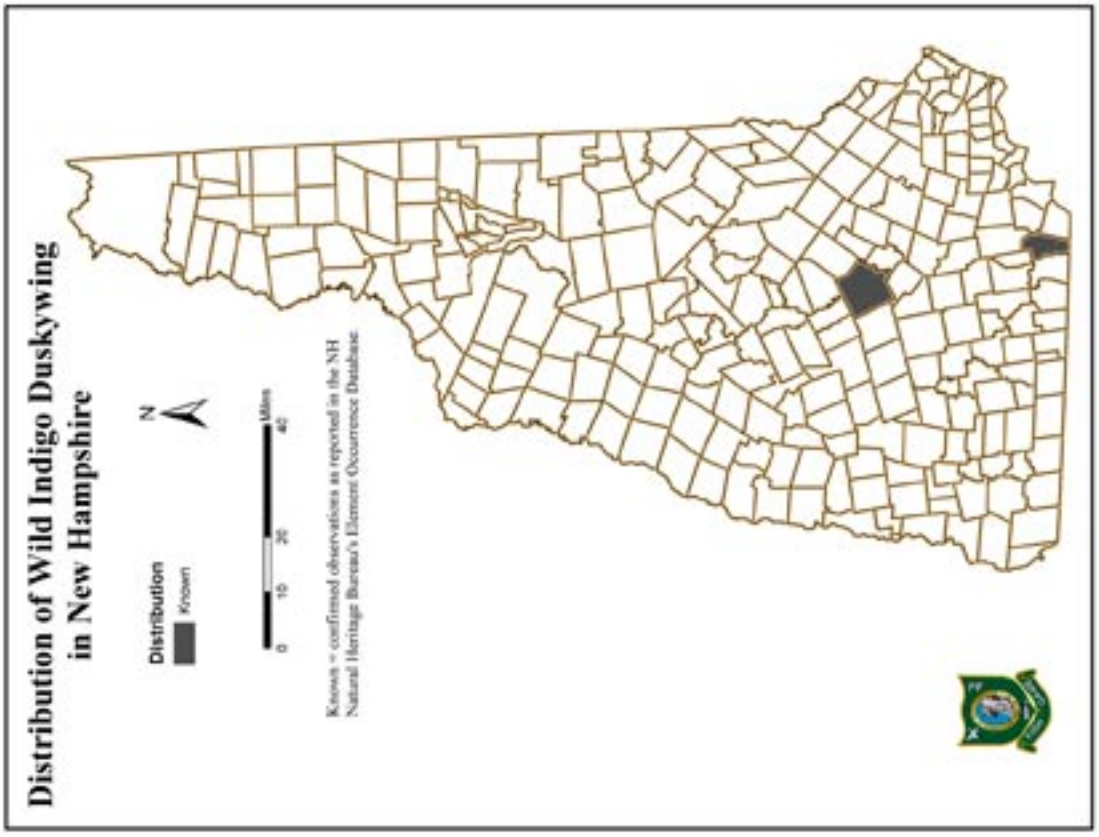

Distribution of Dwarf Wedge Mussel
in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Knows = verified observations as reported in the NH
Natural Heritage Bureau's Element Occurrence
Database.
Potential = appropriate habitat conditions likely to occur.
Historic = observations greater than 20 years old.

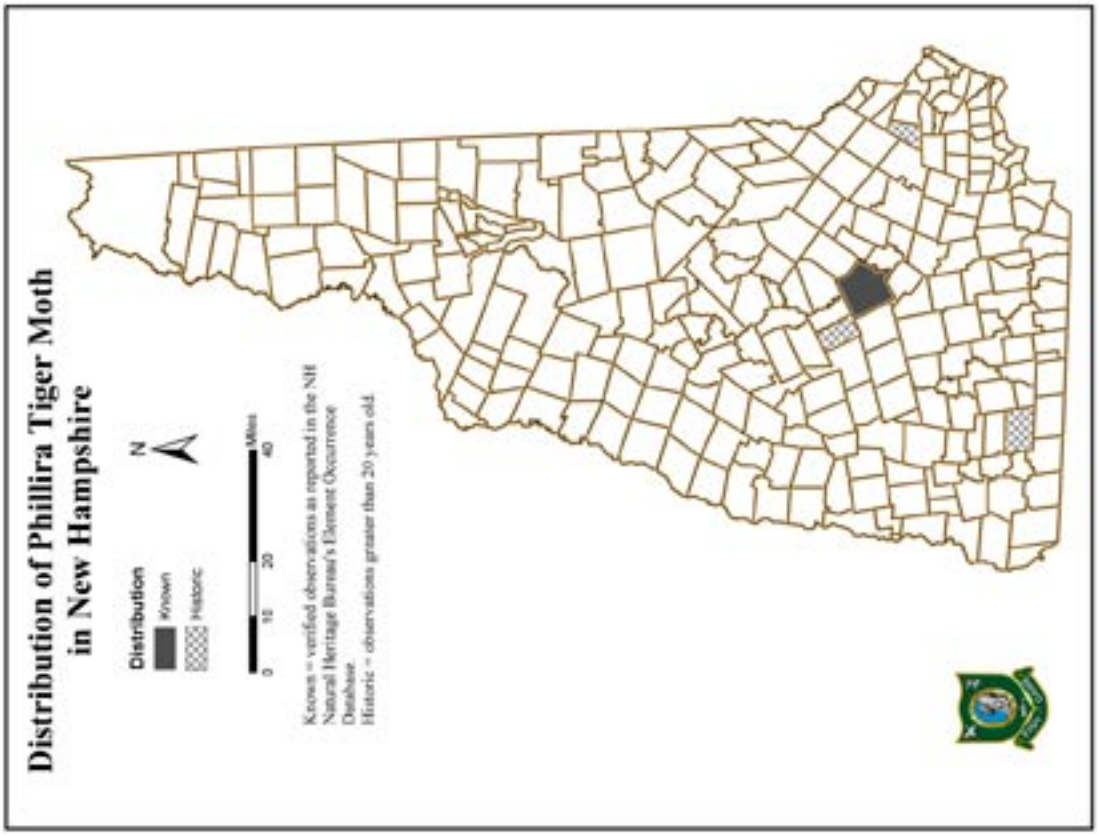

Distribution of Cobblestone Tiger Beetle
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Knows = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database

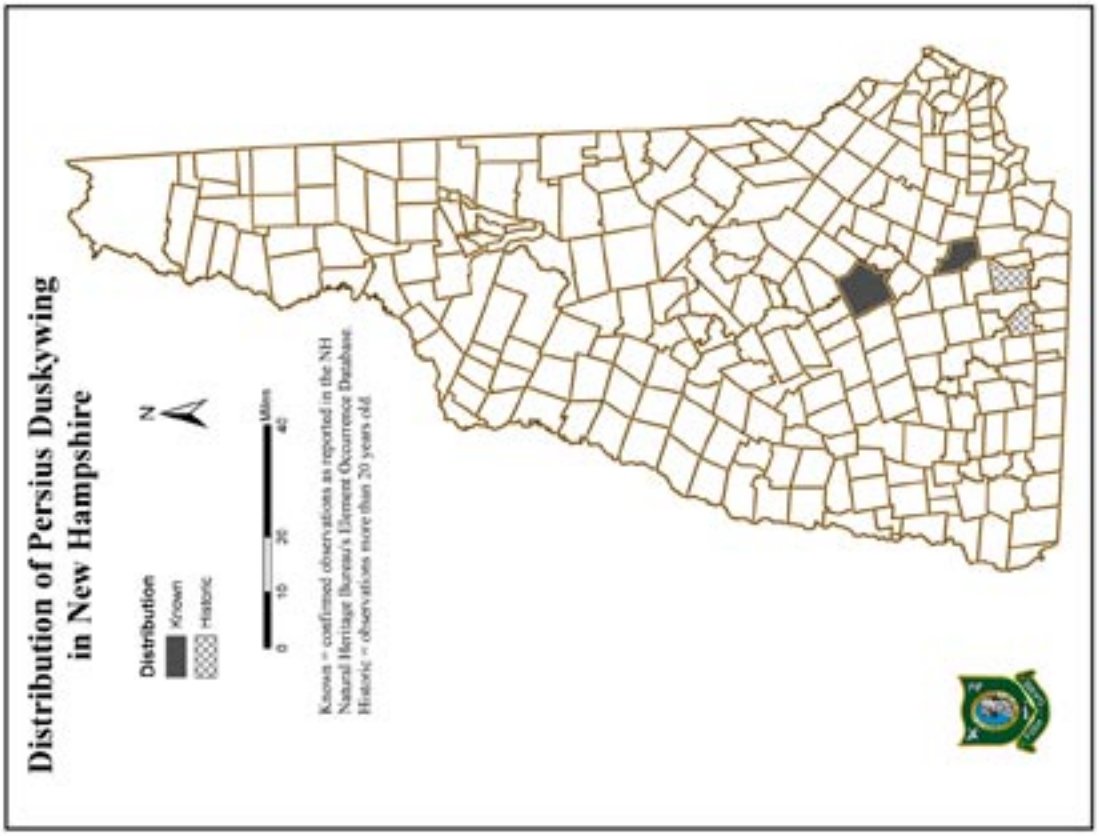

Distribution of Frosted Elfin
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.
Historic = observations more than 20 years old.

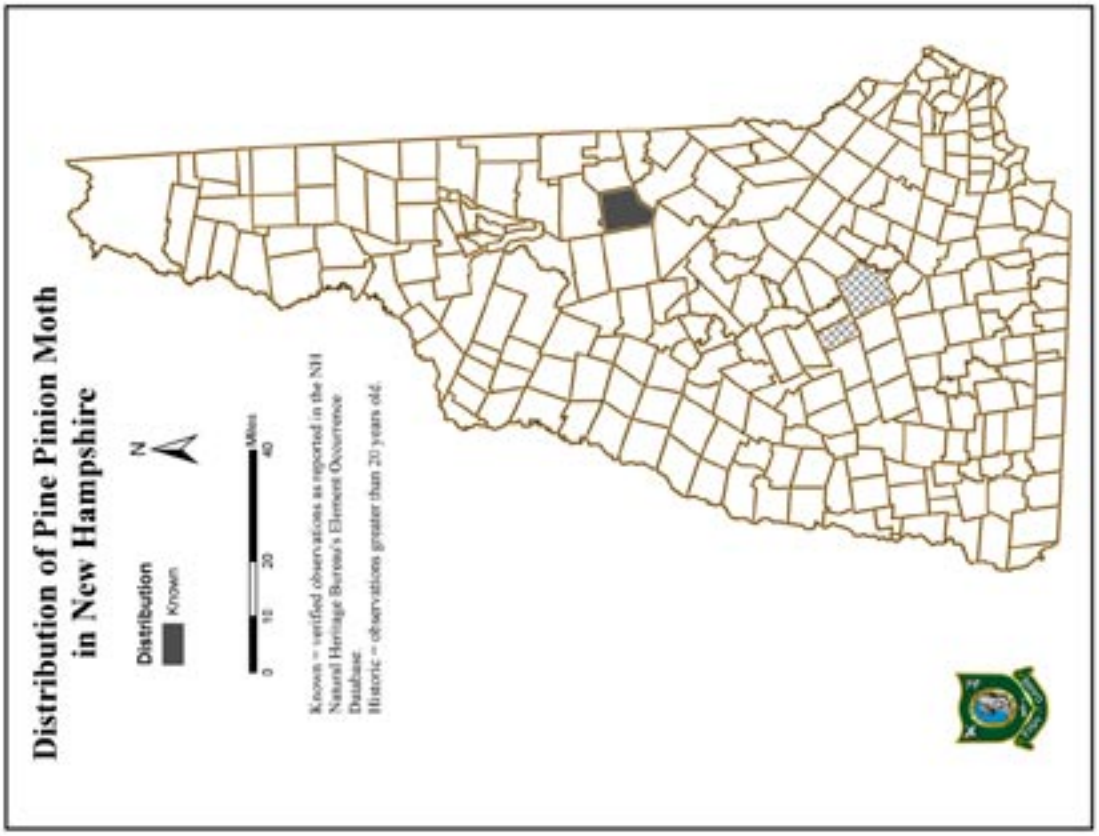

Distribution of Eastern Pond Mussel
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = verified observations are reported in the NH
Natural Heritage Bureau's Element Occurrence Database
Potential = appropriate habitat conditions likely to occur.

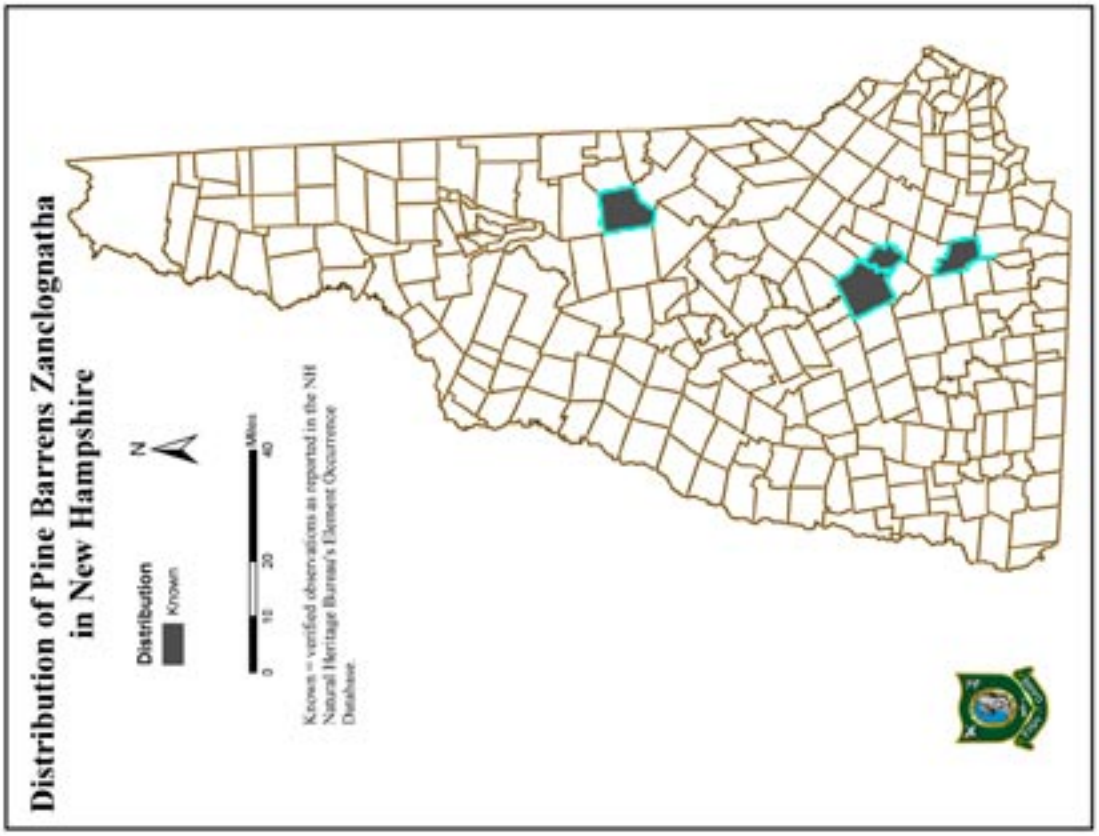

Distribution of Karner Blue Butterfly
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database
Historic = observations more than 20 years old

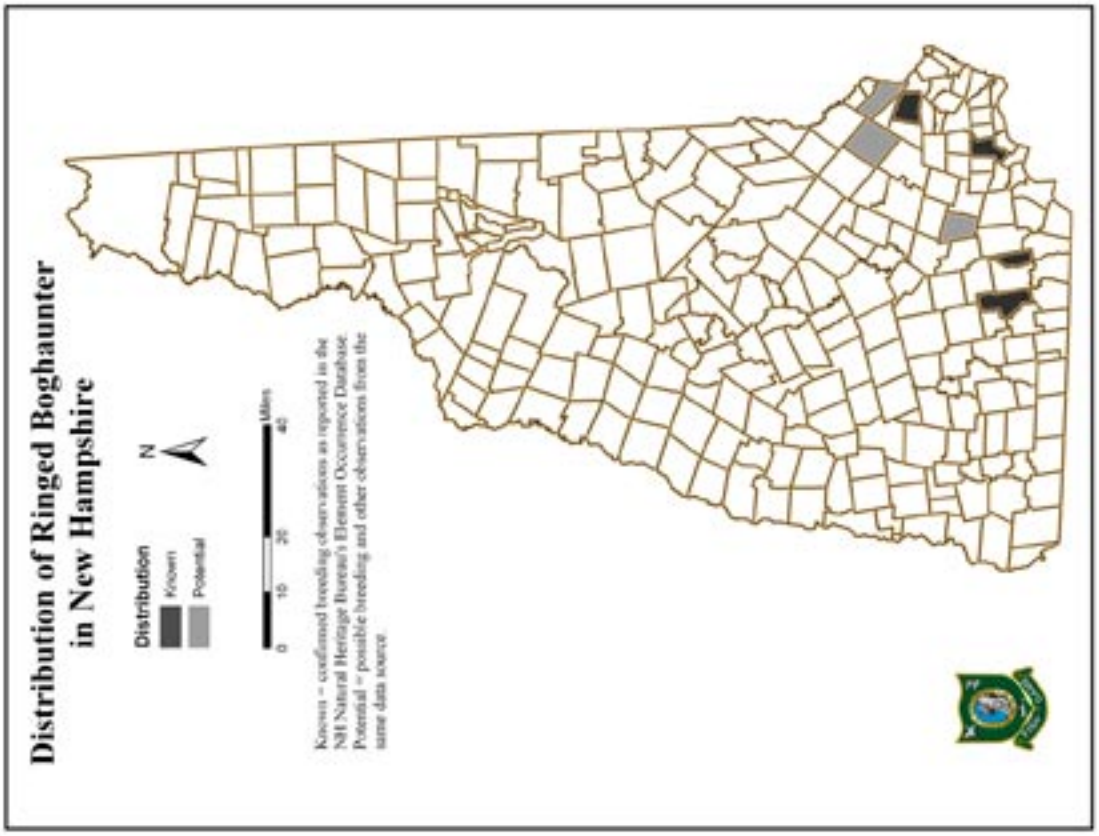

Distribution of Wild Indigo Duskywing
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database

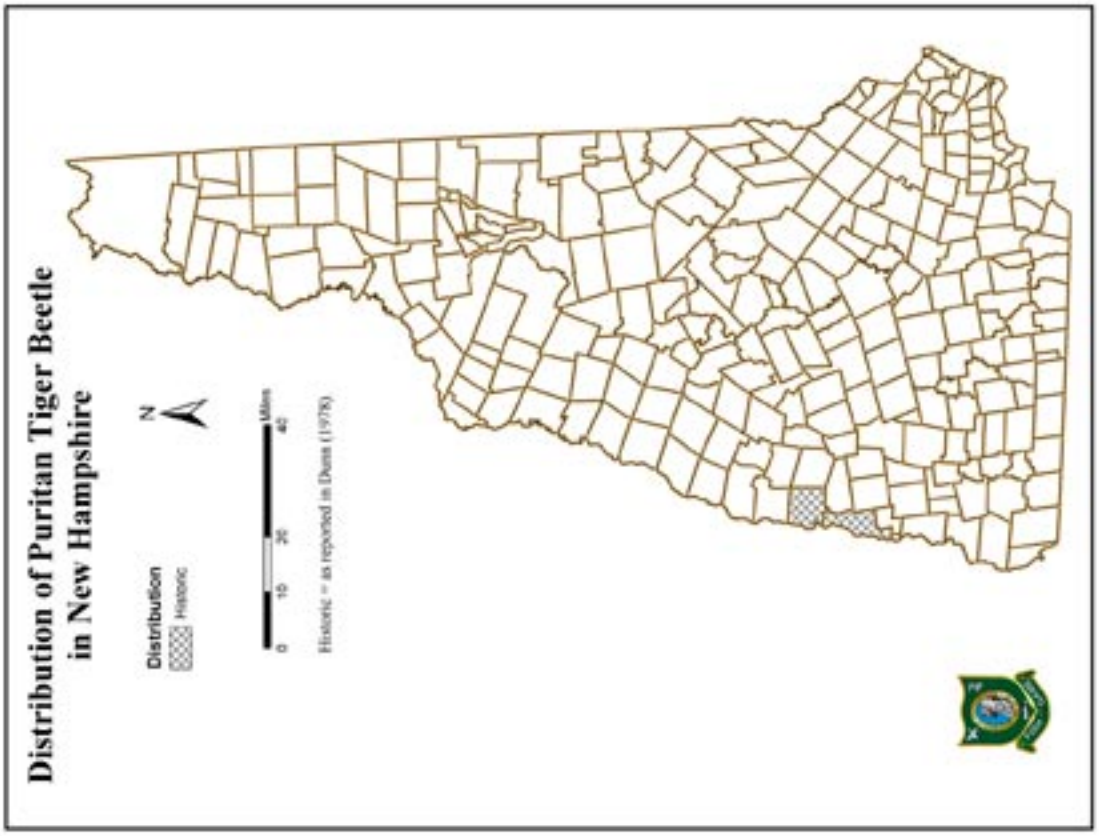

Distribution of Phillira Tiger Moth
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH
Natural Heritage Bureau's Element Occurrence
Database
Historic = observations greater than 20 years old.

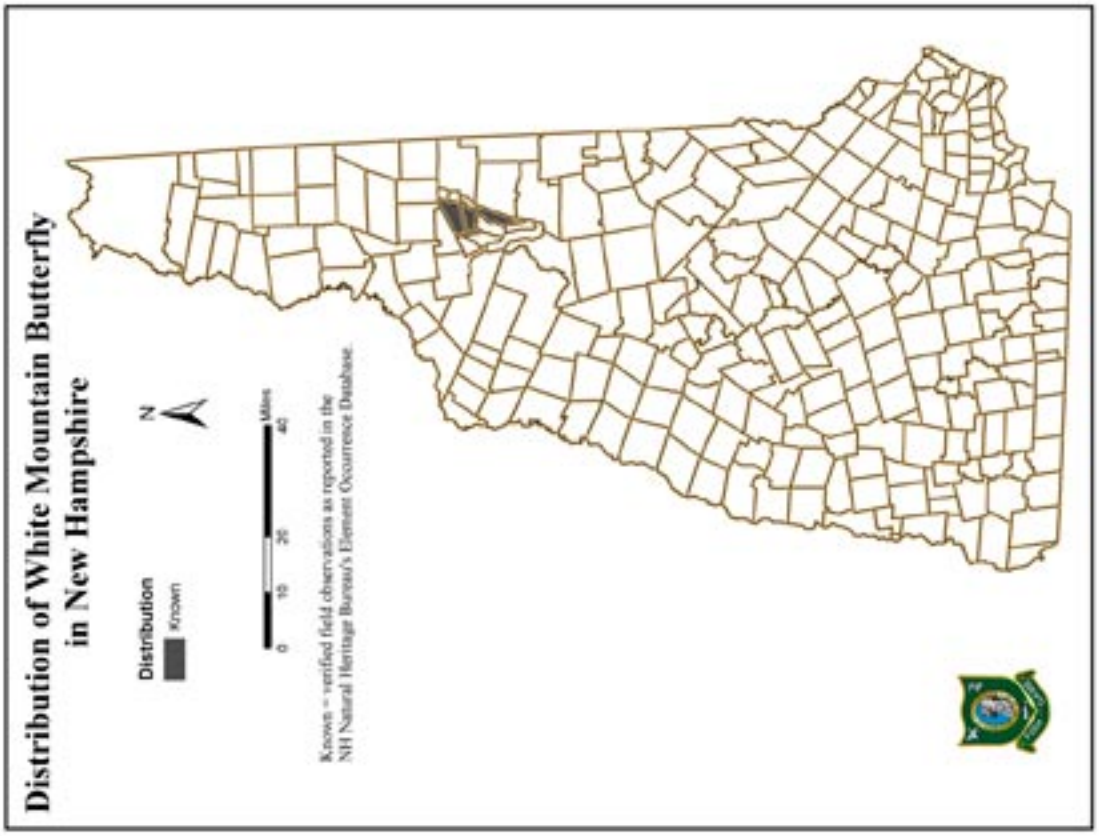

Distribution of Persius Duskywing
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.
Historic = observations more than 20 years old.

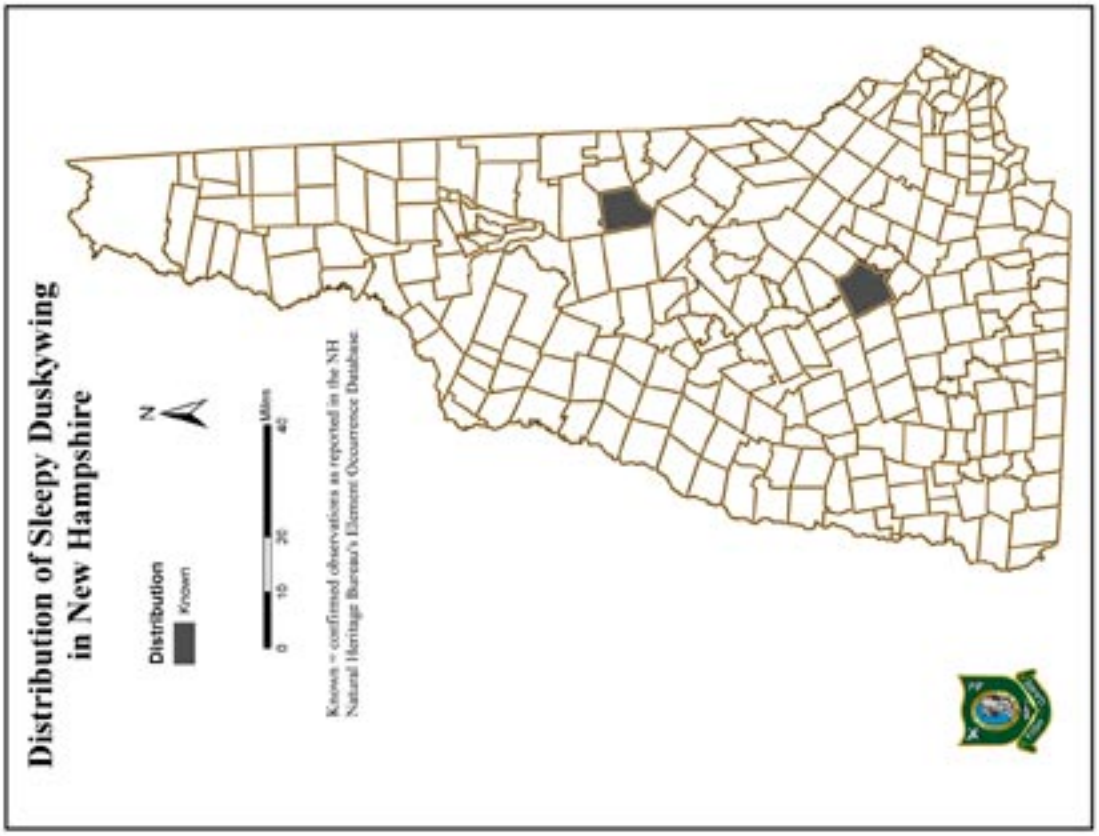

Distribution of Pine Pinion Moth
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Historic = observations greater than 20 years old.

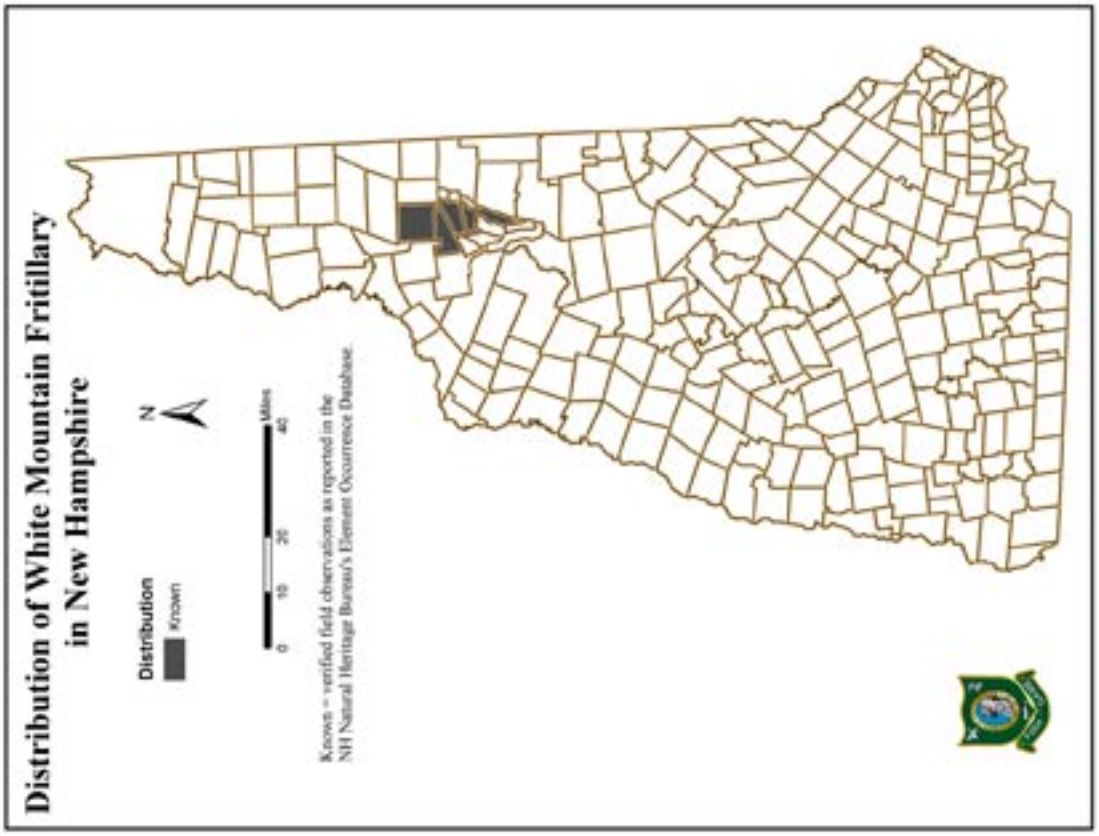

Distribution of Pine Barrens Zanclognatha
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of Ringed Boghaunter
in New Hampshire
Distribution
Known
Potential
N
0
15
30
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Potential = possible breeding and other observations from the same data source.


Distribution of Puritan Tiger Beetle
in New Hampshire
Distribution
Historic
N
0
15
30
40
Miles
Historic = as reported in Dunn (1978)


Distribution of White Mountain Butterfly
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = verified field observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of Sleepy Duskywing
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.


Distribution of White Mountain Fritillary
in New Hampshire
Distribution
Known
N
Miles
0
10
20
40
Known = verified field observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database.